INDIAN WOODS

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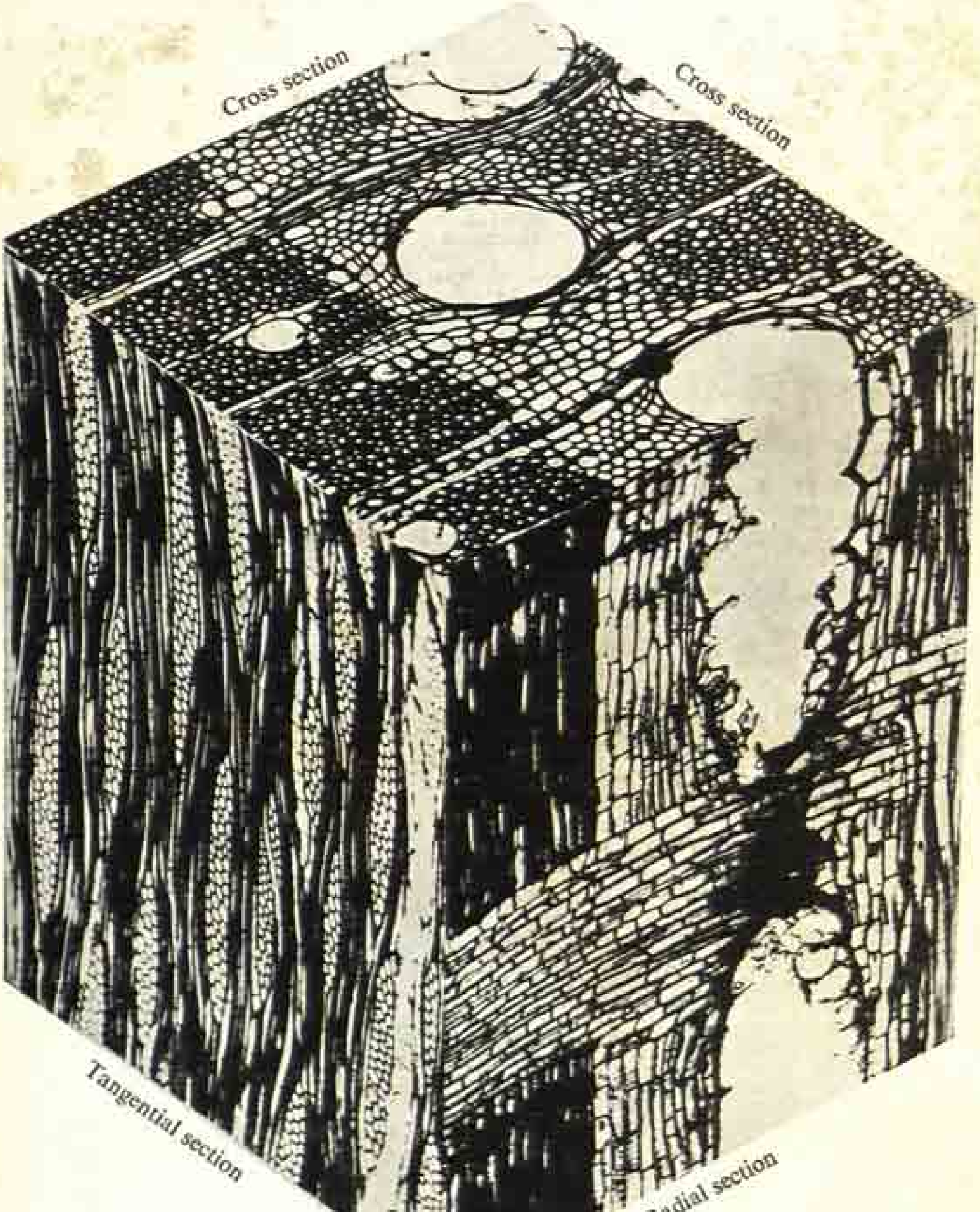

TEAK
Tectona grandis Linn. f.
(× 80)

INDIAN WOODS

Their identification, properties and uses

BY

K. A. CHOWDHURY, D.SC., F.N.I., F.B.S.

AND

S. S. GHOSH, M.SC., F.B.S.

Wood Anatomy Branch

Forest Research Institute, Dehra Dun

WITH THE ASSISTANCE OF

K. RAMESH RAO, M.A., B.SC.,

S. K. PURKAYASTHA, M.SC.,

AND OTHERS

VOLUME I

Dilleniaceae to Elaeocarpaceae

सत्यमेव जयते

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PREFACE

It has been planned to bring out the "Indian Woods" in six volumes, each dealing with about 250–300 species. The aim of the book is to give all up-to-date information on the secondary xylem or wood of the tree species that grow in the Indian sub-continent and which are represented in the Indian wood collection of the Forest Research Institute. Besides wood, the habit and the distribution of the species have also been given in brief. Under the description of the wood we have included the general properties such as colour, hardness, weight, grain and texture, and the anatomical structure as seen with the naked eye or with the help of a hand lens. The anatomical structure visible on the end surface has been described in detail as this is known to be the most useful in identification. The longitudinal surfaces have been utilized only when they show some features of diagnostic importance. In order to include the structural variations that a wood is likely to produce, all the samples belonging to a species in the Indian collection have been carefully studied. Where only a single specimen is available, we have tried to overcome this deficiency by studying the wood samples in our foreign collection. These detailed descriptions should be helpful firstly, to people who want to identify an unknown piece of wood, and secondly, to those who wish to make an approximate estimation of the working qualities of the timbers for which no such data are at present available. In addition, we have also included information on strength, seasoning, natural durability, insect attack, preservative treatment, working qualities, supplies and uses, that has been collected by the various research branches at Dehra Dun. It is hoped that all these anatomical data and other information will be useful to forest officers to enable them to sell many more timber species than they do now, and thus increase the revenue. No less useful should this book be to industrialists, who are keen to use the most suitable timbers for their specific purposes and pay the least for them. In addition, it is believed that botanists, whether engaged in fundamental research or applied research, will find in this book much that will be of interest to them.

The "Flora of British India" by Hooker was the first attempt at giving, in a comprehensive manner, the vegetation of this sub-continent. Hooker's remark that "there is no quarter of the globe so rich in plants" somehow produced a general impression that the timber resources of the country were also enormous. Gamble made a rough estimation and put the number of woody species at 5,000 and tree species at roughly 2,500. Brandis in his "Indian Trees" has described 4,400 species of which 2,514 are trees. However, at present only about 1,600 species are represented in the wood collection of the Forest Research Institute and only these are being described here.

It was Brandis, the first Inspector-General of Forests, who realized the importance of the anatomical study of woods and initiated research on the

subject. The result of this was the publication of the famous book "A Manual of Indian Timbers" by Gamble in 1881. A second edition was brought out in 1902, which was reprinted in 1922 with some corrections and additions. In this edition he gave macroscopic descriptions of 1,450 species. Strength and other data were also included where available. This was the first scientific treatment of tropical timbers and attracted considerable attention not only at home but also from abroad. Then in 1909 Troup's "Indian Woods and their uses" was published giving all available information on the uses of Indian timbers. In 1932 "Commercial Timbers of India" by Pearson and Brown was published. This book which is in two volumes deals with only 320 species. Descriptions of timber are given in much detail, particularly the anatomical structure that is visible under the microscope. Information available at that time on strength, seasoning properties, behaviour to preservative treatment, and working qualities has also been included in this book. The "Common Commercial timbers of India and their uses" by Trotter was also published about this time. This book gives no anatomical data but deals with all other properties and uses. The number of species included in the revised edition published in 1944 is 120, although strength figures have been given for 180 species. Of these four publications, the first two have been out of print for some years now. The third is available for sale but its use is very much restricted. Since its publication, considerable additional information has accumulated as a result of research work carried out at the Forest Research Institute, Dehra Dun. Furthermore, during World War II, when India was cut off from outside world, some common commercial timbers were tried for new uses and many unknown timbers were put into use for the first time. All these experiments supplied important additional data on the properties and uses of many more timbers. Some of these data have no doubt been incorporated in a number of Records, Bulletins and Leaflets issued from time to time by the Institute and also to some extent in Trotter's book. However, it has not been possible to publish all the available information, on a majority of the species. For instance, while sending authentic samples for Gamble's Collection, State Forest Departments have been good enough to supply detailed particulars, such as total height, height of clear bole, diameter at breast height, etc., of the trees from which the wood samples were taken. Further, when the logs or bolts reached Dehra Dun, it was possible to collect valuable information on sapwood, heartwood, appearance and thickness of the bark, etc., before conversion. In this way data from about 3,000 trees have gradually accumulated during the course of last 30 years. Information on number of species so far not described has also been collected in another way. During the course of routine and advisory work on behalf of the timber trade, industries and various Government Departments, including Defence, Railways, etc., the Wood Anatomy Branch had occasion to examine and collect useful data from thousands of wood samples including species previously little known or even

unknown. With all this unpublished data on hand the necessity of having a reference book, in which information on all woody species is available under one cover, has been felt for a long time. Now with the plans for economic development of the country, it has become all the more necessary to make available to trade, industry and the State Forest departments, the latest information on the timber wealth of the country. This task being an enormous one and beyond the capacity of the normal staff of the Wood Anatomy Branch of the Forest Research Institute, the Planning Commission has sanctioned special staff and funds, which have made the preparation and publication of this book possible.

The basis of this reference book is mainly Gamble's collection of woods. When Gamble retired from the Indian Forest Service in 1899, he left behind at Dehra Dun, a large number of specimens as a memorial to his patient, persevering and indefatigable work on wood anatomy. When the senior author joined the Forest Research Institute in 1927, he found these specimens in a good condition. However, in course of daily reference to this collection, it was soon brought home that some of the specimens were not correctly named nor did they belong to the families in which they had been placed. A thorough check of each and every specimen was then made. The result showed that quite a large number were wrong or of doubtful authenticity. Since simultaneous maintenance of herbarium specimens and wood samples was not the practice at that time, there was no other alternative but to destroy them. During the last 30 years, it was possible to add to the Gamble's Collection some 3,000 new specimens. All these are backed by herbarium material. In addition, the Foreign Collection at Dehra Dun has also been of considerable value in the writing up of this book. This collection was started in about 1927 and at the moment contains well over 7,000 specimens. A small collection of commercial samples was also made use of for the writing up of this book. This collection was started some 20 years ago with samples from forest contractors and timber merchants. They are, therefore, by no means what are known as authentic samples and yet experience has shown that they can sometime supply very useful information. In fact, the discovery of *Mansonia dipikae* Purk. from Assam was entirely based on a sample of this collection.

For the number of species dealt with here, some explanation is necessary. Of the 1,600 species described in this book, a few do not occur within the present political boundary of India. Wood specimens of these species were collected and kept at Dehra Dun, when Burma and Pakistan were administratively and politically parts of India. Even now, being neighbours, there is often export and import trade amongst these countries. The information given in this book on these few species will, therefore, be useful to all the three countries situated in this region.

The number of timber species included in this book may create an impression that the quantity of timber available in the country is very large. But

this is not so. Actually the number of timbers available in large quantities is not more than sixty or so, the three most important being teak (*Tectona grandis*), sal (*Shorea robusta*) and deodar (*Cedrus deodara*). A rough idea as to which of these sixty species are available in commercial quantities in different areas or zones of India is given below :—

I. *Uttar Pradesh, Himachal Pradesh and Punjab*—blue pine, kail (*Pinus wallichiana* Syn. *Pinus excelsa*), chir (*Pinus roxburghii* Syn. *Pinus longifolia*), deodar (*Cedrus deodara*), fir (*Abies pindrow*), sal (*Shorea robusta*), sissoo (*Dalbergia sissoo*) and spruce (*Picea smithiana* Syn. *Picea morinda*).

II. *Assam and Bengal*—champ (*Michelia* spp.), chaplash (*Artocarpus chaplasha*), chilauni (*Schima wallichii*), dillenia (*Dillenia* spp.), gurjan (*Dipterocarpus* spp.), hollock (*Terminalia myriocarpa*), hollong (*Dipterocarpus macrocarpus*), kadam (*Anthocephalus cadamba*), lampati (*Duabanga sonneratioides*), maina (*Tetrameles nudiflora*), mesua (*Mesua ferrea*), sal (*Shorea robusta*) and toon (*Cedrela toona*).

III. *Andamans*—gurjan (*Dipterocarpus* spp.), kokko (*Albizzia lebbeck*), padauk (*Pterocarpus dalbergioides*), papita (*Pterocymbium tinctorium* Syn. *Sterculia campanulata*), pyinma (*Lagerstroemia hypoleuca*), white bombwe (*Terminalia procera*), white chuglam (*Terminalia bialata*) and white dhup (*Canarium euphyllum*).

IV. *Madhya Pradesh, Bihar, Orissa and Andhra*—arjun (*Terminalia arjuna*), irul (*Xylia xylocarpa*), sal (*Shorea robusta*), satinwood (*Chloroxylon swietenia*) and teak (*Tectona grandis*).

V. *Madras, Mysore and Bombay*—ballagi (*Poeciloneuron indicum*), benteak (*Lagerstroemia lanceolata*), irul (*Xylia xylocarpa*), kindal (*Terminalia paniculata*), machilus (*Machilus* spp.), mesua (*Mesua ferrea*), pali (*Palaqium ellipticum* Syn. *Dichopsis elliptica*), satinwood (*Chloroxylon swietenia*), rosewood (*Dalbergia latifolia*), teak (*Tectona grandis*), vellapine (*Vateria indica*) and white cedar (*Dysoxylum malabaricum*).

VI. *Scattered all over India*—axlewood (*Anogeissus latifolia*), bahera (*Terminalia bellerica*), babul (*Acacia arabica*), bijasal (*Pterocarpus marsupium*), cutch (*Acacia catechu*), ebony (*Diospyros* spp.), garuga (*Garuga pinnata*), haldu (*Adina cordifolia*), imli (*Tamarindus indicus*), jaman (*Syzygium* spp. Syn. *Eugenia* spp.), jhingan (*Lannea grandis*), kaim (*Mitragyna parvifolia* Syn. *Stephegyne parvifolia*), kanju (*Holoptelea integrifolia*), kokko or siris (*Albizzia* spp.), laurel (*Terminalia tomentosa*), lendi (*Lagerstroemia parviflora*), maharukh (*Ailanthus excelsa*), mahua (*Madhuca* spp. Syn. *Bassia* spp.), mango (*Mangifera indica*), pula (*Kydia calycina*), rajbrikh (*Cassia fistula*), salai (*Boswellia serrata*) and semul (*Salmalia malabarica* Syn. *Bombax malabaricum*).

Prior to 1939, the number of timbers handled by commerce and industry was between 300 and 350. During World War II, this number went up to about 500, when many new industries were established in the country. Immediately after the war there was a tendency to go back to only well-reputed timbers. This reduced considerably the number of timbers in use. However, with the initiation of planned industrial development there is once again a great demand for this raw material. In fact, the timber requirement of India has been, for some years now, far greater than what is available in the market. This scarcity is due to two main reasons. Firstly, lack of transport facilities in the hill forests of the north and in the plains and hill forests of the east and the south, restricts movement of timber to the industrial centres where they are required in large quantities. Secondly, everybody, whether living in rural or urban area, wants only the well-reputed timbers which, as has been pointed out already, are few in number and those too available in limited quantities. In addition, with an All-India plan for industrial development and raising of standard of living in rural areas, scarcity of timber has become a serious problem. Steps have no doubt been taken to create better transport facilities in the forest areas rich in timbers but this will meet the situation only partially. To bring about a satisfactory condition in the timber market, it will be necessary to acquaint people with the properties and uses of timber species that grow in the local forests. This can be done through the agency of Community Development Projects and National Extension Blocks by inducing villagers to make the best use of local timbers. Here it must not be forgotten that over 75 per cent of India's population lives in villages and timber requirement of rural areas is quite enormous. Once villagers are convinced that local timbers are almost as good as the well-reputed timbers, there will be less demand for the latter. From what has been said above it will be apparent why information on 1,600 timber species, some of which may not be bigger than small trees and large shrubs, has been included in this book.

The Government of India decision regarding change over to metric system was received when the first volume of this book was almost ready for the press. This necessitated conversion of all figures into metric system at a late stage which has naturally delayed the publication of the volume by many months. It will take some time for the public to get used to this change over. Therefore to avoid inconvenience to users during the transition period, conversion factors have been provided in appendix I as a footnote.

For the writing up of a reference book of this type, we had naturally to approach many departments and organizations in the country. All of them have given us unstinted help and we are grateful to them. First of all, our acknowledgements are due to the Planning Commission of the Union Government for providing special funds for the writing up of this book. We must also record here our gratefulness to Shri K. L. Aggarwal, President,

Forest Research Institute and Colleges for the keen interest he has throughout taken in the work. Without the help of our colleagues at the Forest Research Institute, this book could not have been written in its present form. One and all have given generous aid whenever sought by us. To all of them we are grateful. However, we wish to place on record our special indebtedness to the following officers of the Institute :—

Shri A. C. Sekhar, Officer-in-Charge, Timber Mechanics Branch has supplied us with the strength data of the species which have been tested in his Branch. Shri M. A. Rehman, Chief Research Officer, Seasoning Branch, has given us all the data he has on the seasoning properties of various species of timbers. Information on the behaviour of timber to preservative treatment has been supplied by Dr. A. Purushotham, Officer-in-Charge, Wood Preservation Branch. He has also given us data on natural durability of timbers based on the 'graveyard' tests. Dr. D. Narayanamurti, Chief Research Officer, Composite Wood Branch, has supplied us with the data on the suitability of various timber species tested by him for plywood. Information on the working qualities of a number of species has also been received from the Service Branch. Dr. M. L. Roonwall, former Entomologist, and Dr. R. N. Mathur, Chief Research Officer, Entomology Branch and Dr. B. K. Bakshi, Officer-in-Charge, Mycology Branch, have supplied us from their records valuable information on the susceptability of various woody species to insect and fungus attack. Shri M. S. Srinivasan, the former Silviculturist and Shri S. K. Seth the present incumbent allowed us the facilities to consult their ledger-files as and when required. The latter has also taken the trouble of preparing a map of India showing the forest areas under regular managment. Dr. K. R. Nair, Statistical Branch, gave us advice on matters relating to the question of presentation of data. Finally, special mention must be made of the generous help given by Shri M. B. Raizada, Officer-in-Charge, Botany Branch and Shri R. N. Chatterjee also of the same Branch. The task of supplying latest nomenclature of the species included in this book fell on these two officers. Knowing fully the difficulties that they had to encounter in carrying out this task, we are deeply grateful to them.

Acknowledgements are also due to the territorial forest officers of the states who have taken the trouble to collect authentic wood samples for the Forest Research Institute. It is due to their labour and interest that 3,000 wood samples could be gathered for the Gamble collection. Information supplied by them has all been included in this book and is sure to be useful to all. In addition, we are also indebted to other members of the forest service who have passed on much useful information to the authors in course of discussion either at Dehra Dun or while on tour in their forests.

It now remains for us to put on record the help rendered to us by the various members of the Wood Anatomy Branch. First of all, we wish to

acknowledge the help given by Shri S. K. Purkayastha, who was specially appointed as a whole time officer to help us with the writing up of this book. Shri Purkayastha had to handle all types of work in connection with this book and we must say that he has done it well. Without the hard work he has put in, it would not have been possible to complete the work in time. Shri P. N. Nigam and Shri M. S. Rawat, the two other full time research workers appointed under this Scheme have helped us loyally throughout this period. Shri R. P. Pande, who was appointed to look after the correspondence and typing work, has made an excellent job of it. Shri Jahan Singh, Curator, Timber Collection has given every assistance to all the workers for consulting timbers in the collection. We are grateful to Shri K. Ramesh Rao, Research Officer, for the many ways he has helped us in the laboratory as well as in the preparation of the manuscript. Names of the other members of Wood Anatomy Branch, who have taken part in the writing up of the book, will be found at the end of each family. We are grateful to all of them for the spirit of team work shown by them.

The quality of the photomicrographs is a testimony of the careful and patient work done by the Baptist Mission Press, Calcutta, who were entrusted with this job. They have been extremely co-operative and helpful at every stage of block-making and printing. We are deeply grateful to them.

In the end, we wish to offer our sincere thanks to the Director, Northern Circle, Survey of India, for undertaking the printing of this book at the Survey of India Press, Dehra Dun. We are specially grateful to Shri P. N. Kirpal, Manager, Photo-Zinco Press, who has taken keen interest and considerable pains over many details in connection with the printing of the book.

Forest Research Institute,
Dehra Dun.
1st June, 1957.

K. A. CHOWDHURY,
S. S. GHOSH.

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INTRODUCTION

It is not definitely known when man first began to use wood. Some authorities are of the opinion that this practice started during the Old Stone Age, when man was on the look out for a digging tool in his search for food[1]. During this age he also probably learnt the use of fire for which wood was undoubtedly necessary. But these are only assumptions. Actual evidence of the use of wood by man has been recorded for the first time, from the excavation of the sites of New Stone Age. In the Indian sub-continent no site of the Stone Age has so far produced any evidence of the use of wood. Our earliest record goes back to only proto-historic period, that is, from 3,000 B.C. to early historic era. In this period we find men of the Indus Valley civilization[2] using wood for many purposes.

Of all the archaeological excavations of the proto-historic period in India, two are of considerable interest namely, Harappa, a full-fledged Bronze Age civilization and Hastinapura, a Copper Age civilization. The variety of uses to which wood was put at these sites, leads one to infer that experience of thousands of years must have been behind the people of these ages to give them such an insight into the properties of different timbers. In many cases they seem to have made the most efficient use of timbers even judged according to modern standards. The use of deodar (*Cedrus deodara*) and rosewood (*Dalbergia latifolia*) by the Harappans for making a coffin has been reported[3]. This indicates a knowledge of the durability of some scented woods which even to this day are being used for the same purpose after thousands of years. Further, the use of ber (*Zizyphus* spp.) for wooden mortar for pounding grains reveals that the Harappans were not only aware of the shock absorbing quality of this timber but also of the fact that this is one of the few woods that season well in the form of logs and is, therefore, particularly suitable for the purpose. Although the wood remains from Hastinapura[4] do not clearly indicate whether these were used as firewood or charcoal yet there is little doubt that the people of this Copper Age civilization had some idea of the woods that have high calorific value. The two timbers sissoo (*Dalbergia sissoo*) and kurchi (*Holarrhena antidysenterica*) recovered from this excavation are considered even today to be good fuel woods.

Near about the dawn of early historic period we find some more wood remains which throw further light on the knowledge the people of that time

1. E. Adamson Hoebel. Man in the primitive world. McGraw Hill Book Co., 1949.

2. Sir John Marshall. Mohenjo-Daro and the Indus civilization, Vol. 1–3. London, 1931; M.S. Vats, Excavations at Harappa, Vol. 1–2, Calcutta, 1940.

3. K. A. Chowdhury and S. S. Ghosh. Plant remains from Harappa 1946. *Ancient India*, No. 7, 1951.

4. K. A. Chowdhury and S. S. Ghosh. Plant remains from Hastinapura 1950–52, *Ancient India*, No. 10 and 11, 1954–55.

had of the properties and uses of timber as evidenced by the exclusive use of sal (*Shorea robusta*) piles for wooden palisades at Pataliputra[1]. Sal has the reputation of being one of the most durable timbers in contact with soil. This special quality of sal must have been known to them. Further, microscopic study of the piles showed that the quality of sal used was also excellent. In view of the wide variation in quality found in sal, it is reasonable to conclude that the people of this period not only knew what constituted the best sal but also where it was produced. Similarly, the use of *Acacia* for the construction of a wooden gate at Sisupalgarh[2] in Orissa is another instance which shows that the people of the early historic period were not unfamiliar with the strength and durability of this timber.

Apart from direct archaeological evidence from excavations referred to above, there are considerable references to uses of wood in our ancient literature. The Vedic literature of the Aryans gives much information on the domestic and the religious life of the people, including detailed instructions regarding timbers to be used for various purposes. For making thrones for kings certain timbers are specifically recommended while others are tabooed ; only strong and durable timbers have been advocated, the weak and non-durable timber being considered inauspicious. Similar instructions regarding timbers to be used and those to be avoided for making various components of beds have been clearly laid down in Vedic literature[3]. This is probably the first record in ancient Indian literature which shows that our ancestors must have been familiar with the seasoning properties of different timbers. We also come across mention of people using boats and ships for pleasure as well as for commercial purposes. Instructions for the selection and handling of various woods for boat and ship building[4] are also given, which show that experiments must have been carried out for years and years for drawing such sound conclusions. Again, it is interesting to note in this connection that the first written record of the existence of a class of craftsmen in society known as *vaddhaki* or carpenters is met with in Vedic literature. In summing up it may be pointed out that if the Vedic Age claims priority for the knowledge of the rotation of agricultural crops, there are now enough data available to show that the people of India of a much earlier age could claim priority to a sound knowledge of efficient wood utilization. The date for this may approximately be put to a time about 5,000 years from now.

After having given briefly some idea of the role played by wood at different stages of early Indian Civilization, the next few pages will be devoted to our present knowledge on various scientific aspects of wood utilization in India.

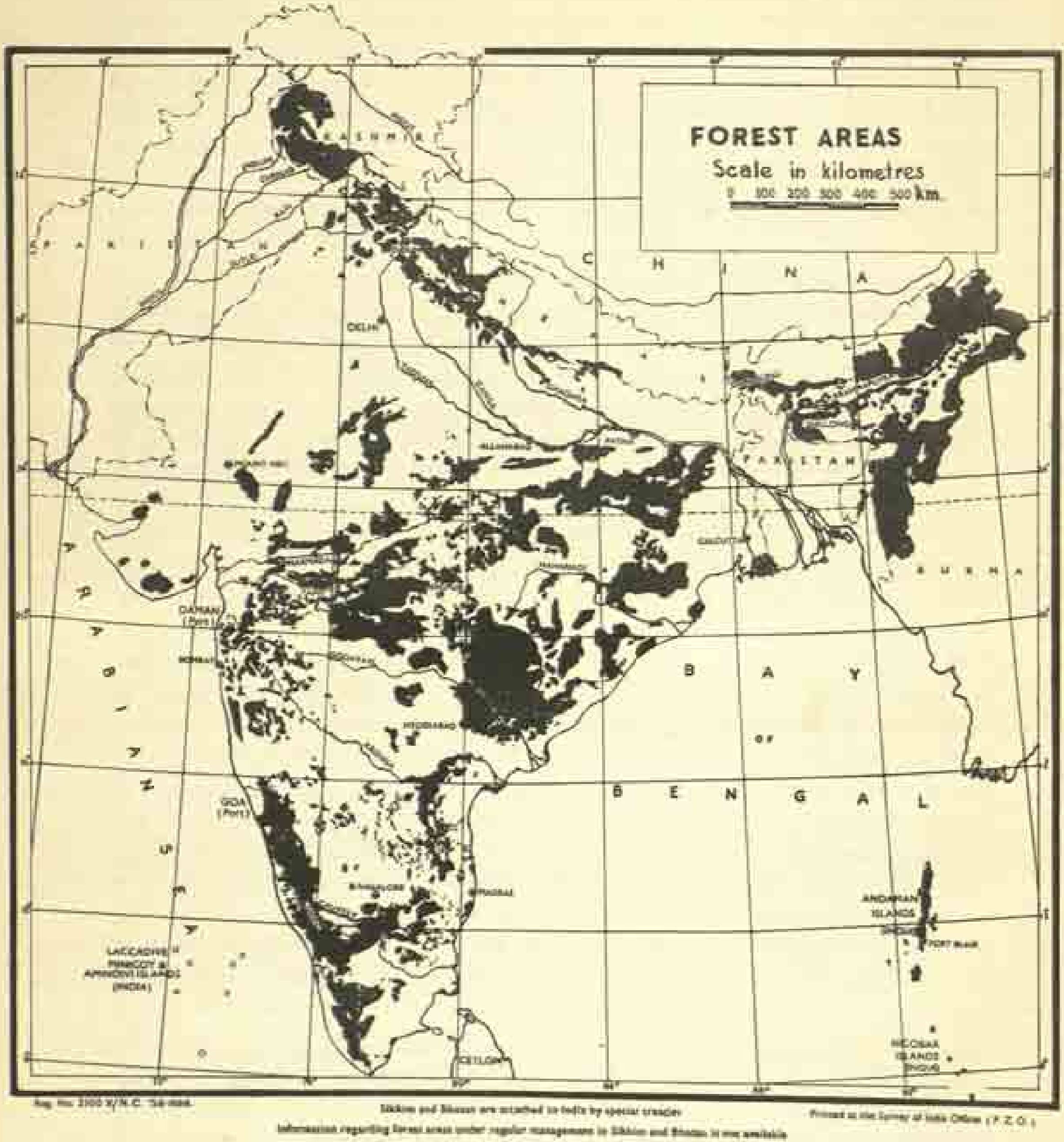
---

1. K. A. Chowdhury and S. S. Ghosh. Unpublished data.

2. K. A. Chowdhury and S. S. Ghosh. Wood remains from Sisupalgarh. *Ancient India*, No. 8, 1952.

3. G. P. Majumdar. Some aspects of Indian civilization, Calcutta, 1938.

4. Radhakumud Mookerjee. Indian Shipping – a history of the sea-borne trade and maritime activity of the Indians from the earliest times. Longmans Green & Co., London, 1912.



Sikkim and Bhutan are attached to India by special treaties

Information regarding forest areas under regular management in Sikkim and Bhutan is not available

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SKETCH MAP OF INDIA SHOWING FOREST AREAS UNDER REGULAR MANAGEMENT.

AREA

As the main source of supply of Indian woods is from forests, it is necessary to have some idea of the area under forest cover. In 1932, Pearson and Brown gave the forest area of India as 239,700 sq. miles (approximately 62 million hectares). In 1954 the forest land in India has been estimated to be 282,840 sq. miles (approximately 73 million hectares)[1]. This difference between 1932 and 1954 is due to the exclusion of Burma and Pakistan and inclusion of area under the princely states and private forests. Within the present political boundary of India, the area under forest is estimated to be 22·3 per cent of the total area.

CLIMATE

It is now well recognized that there is a direct relation between the climate of a country and its forest vegetation, but the importance of the effect of climate on timber utilization is not always realized. This may not be a serious matter in a country where climatic conditions are more or less equable throughout the year. But not so in India, where climatic conditions "probably show more variation than those of any other tract of similar area in the world"[2]. To cite a few examples, the annual average rainfall at Cherrapunji in Assam is 10,871 mm. (428 in.), while that at Buili in Rajputana is only 76 mm. (3 in.). In spite of this wide variation, there is a similarity in the seasonal cycle of different regions. Roughly four seasons are recognizable, the monsoon being the most important in its effect throughout the country.

From December to February the temperature in the north is between 10°C. (50°F.) and 13°C. (55·4°F.) and in the south about 27°C. (80·6°F.) or less. The days are cool with bright sun-shine. There is some snowfall on the hills of the north and some rainfall in the plains of the foot-hills. In April and May, the temperature goes up throughout the country. In May, the whole of northern India experiences very hot climate, the temperature sometimes going up to 43°C. (109·2°F.) and over. In June, the rains start in the south with the onset of the monsoon and reach the north in about four weeks' time. The highest rainfall is in July and August. Then gradually the monsoon retreats. In October the temperature is seldom over 27°C. (80·6°F.) throughout the sub-continent. As a rule, the difference in rainfall of different places is much greater than that of temperature. To give a general idea of variation in temperature, rainfall and humidity throughout the year in different parts of India, the data based on the information collected by the Meteorological Department[3] for some typical localities are given in Table A.

---

1. Forestry in India 1953–54. Issued by Economic & Statistical Adviser, Ministry of Food & Agriculture, New Delhi, 1954.

2. R. S. Troup. Silviculture of Indian Trees, Vol. 1, Oxford, 1921.

3. Indian Weather review 1948. Published by the Government of India.

TABLE A.—*Average rainfall, temperature and humidity of some localities in India*

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BOMBAY	Rainfall in mm. ..	4	2	1	1	17	484	616	340	264	65	13	2
	Temperature °C. Max.	28·4	28·3	30·1	31·7	32·8	31·3	29·7	29·4	29·7	31·5	31·8	30·3
	Min.	19·2	19·6	22·1	24·5	26·4	25·8	24·8	24·5	24·2	24·2	22·5	20·4
	Humidity % ..	73	74	76	78	77	82	86	86	88	84	76	73
CALCUTTA	Rainfall in mm. ..	9	30	35	44	139	297	325	328	253	114	21	5
	Temperature °C. Max.	26·4	28·7	33·6	36	35·3	33·5	31·9	31·6	32·1	31·7	29	26·3
	Min.	12·5	15·2	20·4	24·1	25·2	25·8	25·8	25·7	25·5	23·2	17·6	12·7
	Humidity % ..	85	82	79	76	77	82	86	88	83	85	79	80
CALICUT	Rainfall in mm. ..	9	5	17	91	236	840	824	436	202	261	139	26
	Temperature °C. Max.	31·05	31·3	32·2	32·7	32·2	29·2	28	28·2	29·1	30·1	30·7	30·9
	Min.	21·6	22·7	24·5	25·7	26·2	23·9	23·3	23·5	23·6	23·7	23·2	21·8
	Humidity % ..	81	82	79	80	83	92	95	94	91	89	85	80
DELHI	Rainfall in mm. ..	25	21	13	8	13	77	179	185	123	10	3	11
	Temperature °C. Max.	21·3	23·7	29·4	35·8	40·4	39·1	35·1	33·8	34·1	33·6	28·4	23·1
	Min.	6·2	9·5	13·9	19·8	26	28·05	27·1	25·7	24·1	17·9	11	7·2
	Humidity % ..	68	71	55	40	39	24	77	80	74	58	53	67

(*contd.*)

TABLE A.—*Average rainfall, temperature and humidity of some localities in India*

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
KANPUR	Rainfall in mm. ..	14	17	7	6	8	81	159	284	172	33	9	7
	Temperature °C. Max.	22·1	25	31·8	37·4	41·2	39·2	33·5	32·05	32·7	32·8	28·2	23·3
	Min.	7·6	10·5	15·6	21·4	26·8	28·3	26·6	25·9	24·5	18·8	12·1	8·05
	Humidity % ..	81	71	48	36	40	61	86	90	85	71	70	80
MADRAS	Rainfall in mm. ..	36	10	7	15	26	47	91	116	119	306	355	138
	Temperature °C. Max.	29·6	31·2	33	35·2	38·5	37·5	35·7	34·8	34·3	32·2	29·6	28·9
	Min.	19·5	20·2	22·4	25·6	27·6	27·2	26·2	25·5	25·1	23·8	22·1	20·5
	Humidity % ..	87	83	80	74	63	59	65	71	75	83	86	87
NAGPUR	Rainfall in mm. ..	9	17	15	15	19	224	371	290	203	55	20	12
	Temperature °C. Max.	28·7	31·2	35·7	40·1	42·6	37·5	31	30·7	32·1	32·6	29·7	27·6
	Min.	13·3	15·5	19·3	23·6	27·2	26·4	24·1	23·9	23·4	19·2	15·1	12·1
	Humidity % ..	57	54	36	37	32	59	83	78	75	62	59	59

It is a common experience in this country that doors, windows and drawers stick during the rainy season when the humidity is comparatively high. This is because wood being a hygroscopic substance swells and shrinks when subjected to changes in heat and humidity due to variation of temperature and rainfall of the locality in which it is used. The effect of climate on wood is two-fold. Firstly, freshly felled or green timber is full of moisture. A greater portion of this must be removed before the timber reaches a state of steadiness and becomes fit for use. During the process of seasoning or drying, the climatic conditions play a great part. In a locality with high temperature and low humidity, the seasoning is usually quick, whereas, under conditions of low temperature and high humidity the process is slow. Incidentally, this method of drying wood under atmospheric conditions is known as air-seasoning. In India air-seasoning is of great importance and the majority of people have to depend on it as the facilities for kiln-seasoning are very limited.

Secondly, even after the timber has been dried or seasoned according to the conventional practice of bringing it down to 12–15 per cent moisture content, the component parts of a wooden article often continue to swell and shrink for some time. The reason for this was not at first apparent. But well-planned experiments laid out in different parts of India have thrown considerable light on the effect of climate on timbers in actual use[1]. The results of these experiments have been summarized by Rehman as follows :—

"It has been found that there is a considerable difference in the seasonal variation of the moisture content of different timbers in different localities, and that this variation depends on the species of timber, the size of the pieces, and the climatic conditions of the locality where the wood is used. The seasonal fluctuation of moisture content varies from 3·6 per cent to 14·5 per cent in the different localities where the tests were made. Timbers like *Tectona grandis* (teak) and *Dalbergia sissoo* (*sissoo*) are slow to change their moisture content as a result of changes in atmospheric humidity, whereas a timber like *Cedrela toona* (*toon*) responds to changes of atmospheric humidity very quickly. The timbers, which are least susceptible to changes in atmospheric humidity, give least trouble in use from swelling and shrinking of the component parts of the finished article.

"Based on the results of this survey and from a knowledge of the maximum and minimum atmospheric humidities prevailing during the year in different localities, the whole country can be divided into four distinct zones with regard to the moisture content of seasoned timber for interior wood work.

"In the dry zones of the country, such as in the Punjab and Rajputana, wood should be seasoned to about 7 or 8 per cent moisture content for general carpentry and cabinet making. For use in the coastal regions, and in the moist

1. M. A. Rehman. Survey of the seasonal variation of the moisture content of Indian woods *Ind. For. Rec.* (N.S.) 2, 10, 1942

parts of Bengal and Assam, timber should be seasoned to 13 or 14 per cent moisture content, and for use in the plains of the United Provinces and Bihar, wood should be seasoned to 10 per cent moisture content. In the moderately moist parts of Bengal and Bihar wood should be seasoned to about 12 per cent moisture content".

It will, therefore, be seen that for efficient utilization of timber, proper seasoning is a matter of great importance. Somehow the necessity of using seasoned wood has not so far received the attention it deserves in this country. As a result, many otherwise good timbers have been condemned because they swell, shrink, crack and warp and cause considerable inconvenience to users. Everybody wants to get Burma teak because it gives the least trouble. But it is not realized that Burma teak takes 4–5 years to reach Rangoon after it has been girdled and felled. By the time it reaches India the timber is more or less well seasoned. It is, therefore, no wonder that Burma teak is a steady timber and gives the best service. Indian teak does not go through the same processes as Burma teak and is usually used green or nearly so. The result is that Indian teak is considered inferior to Burma teak. Much of this wrong impression would disappear if more attention is paid to the proper seasoning of Indian teak before it is used. What is necessary for teak, is probably more necessary for other timbers, which are usually not so good in their seasoning properties. The blame does not so much lie with the wood as the people who handle timbers and do not give them a fair chance.

WOODY SPECIES AND THEIR DISTRIBUTION

It was Brandis who dealt with the woody species of India in considerable detail in his standard book "Indian Trees". This was followed by "Silviculture of Indian Trees" by Troup. Later, Champion classified Indian forests in his "Preliminary survey of forest types of India and Burma". These publications give more or less a complete picture of the distribution of trees and shrubs of the present time. In this context, the result of some recent researches on the plant remains of the past are of considerable interest. Since the Middle Tertiary Period some species seem to have migrated hundreds of miles towards south and east from eastern India, while others have remained more or less stationary[1]. Further, the study of plant remains from excavations at Harappa and other places indicates that there has not been any marked migration of perennial plants during the last 4,000–5,000 years[2].

In the preface an attempt has been made to give the source of supply of some sixty most important commercial timbers. For the remaining species one has to depend mostly on local floras. A study of these floras reveals the

1. K. A. Chowdhury. Tertiary Floras and problems of regional phytogeography in Eastern India, *Proceedings of Seventh International Botanical Congress*, 1950; on the Tertiary Flora of Eastern India, *Palaeobotanist*, Vol. I, 1953.

2. K. A. Chowdhury & S. S. Ghosh. Plant remains from Harappa, *Ancient India*, No. 7, 1951.

interesting fact that the vegetation of the evergreen forests of Assam closely resembles that of the west coast forests of Bombay, Mysore and Kerala, even though they are widely separated. For instance, many species like *Bischofia javanica, Chukrasia tabularis, Grewia microcos, Lagerstroemia flos-reginae, Trewia nudiflora, Acrocarpus fraxinifolius, Mesua ferrea*, and *Tetrameles nudiflora* grow only in Assam and west coast. Again, there are some genera like *Ailanthus, Atalantia, Canarium, Pterospermum, Mastixia, Memecylon, Aglaia, Alseodaphne, Amoora, Cynometra, Dipterocarpus, Heritiera, Cinnamomum, Dysoxylum*, etc., which though represented in both the regions, the species are often different. However, as the woods of these species closely resemble each other in anatomical structure, they are likely to have similar properties. Hence, from the point of view of utilization, experience gathered in one locality can be profitably used in the other without further experiments.

BOTANICAL CLASSIFICATION AND NOMENCLATURE

The system of classification followed in this book is based on that of "Genera Plantarum" by Bentham & Hooker. In India all the floras and herbaria follow this system, and so does Brandis in his "Indian Trees", which is the main source of information on systematic and other aspects of the species dealt with here. Since the introduction of Bentham & Hooker's system, taxonomists have made many improvements. Rearrangements within some families have been made and many new families have been created by grouping genera and species. We have, therefore, followed the classification given in "Anatomy of Dicotyledons" by Metcalfe and Chalk as all the latest improvements approved by the Royal Botanic Gardens, Kew, are incorporated in this book.

The authors being anatomists encountered many difficulties on the question of nomenclature and had to depend on systematists for help. Even for the taxonomist, the task is not an easy one as so aptly put by Professor Burges and Dr. Heywood[1]. "The position is such that to answer almost any question on European taxonomy the specialist has to refer to upwards of fifty Floras and countless papers and then synthesize the resultant information. This is time-consuming enough for the professional taxonomist who knows the literature well and who has it available (and there must be few indeed who would claim this distinction today), but for the workers in other fields such as evolution, phytogeography, etc., who are dependent on easily accessible taxonomic data, the position is almost intolerable. Only the large national herbaria can afford to stock the necessary literature, and the number of taxonomists with adequate training and experience of European taxonomy as a whole is, rightly or wrongly, so small as to constitute a distinct problem". In these circumstances, the authors may be excused for the mistakes in nomenclature that may have

1. N. A. Burges and V. H. Heywood. A flora of Europe, *Nature*, 179, 4562, pp. 696-7, 1957.

crept in this book in spite of all the precautionary measures taken by them. To give an idea of the problems that they had to face, a few examples given below will suffice. The old genus *Sterculia* L. has now been split up into a number of genera of which five are reported to grow in India, namely *Pterygota* Endl., *Pterocymbium* R. Br., *Firmiana* Marsigli, *Scaphium* Endl., and *Sterculia* L. The genus *Bombax*, in part, has been changed into *Salmalia* Schott & Endl. and the two Indian species so far placed in the latter have become *Salmalia malabarica* Schott & Endl. and *S. insignis* Schott & Endl. Whereas, the position of the Burmese species *Bombax cambodiense* Pierre and the Indian species *Bombax scopulorum* Dunn does not appear to have been decided. Again, *Calophyllum tomentosum* Wight which was once reported from India is now said to be growing only in Ceylon while the Indian species originally described under that name is now called *C. elatum* Bedd. Such instances are too numerous to be dealt with here.

All these changes in nomenclature have created considerable difficulties for giving the exact distribution of species. Wherever possible, alterations in the distribution have been made. However, in cases where the present species forms only a part of the species originally described under that name, this has not been practicable. To wait for the final solution of these problems would have meant postponing this publication for a decade or more. Even then, the book would not have been free from criticism from the point of view of nomenclature, because, while in press some names might be regarded as out of date. Taking all these points into consideration, the authors have decided to follow the nomenclature as given in the "Indian Trees" by Brandis. Where-ever possible, the latest names have been given under each species in brackets. Here it may be mentioned that when the first volume of the book was almost half through the press, the Forest Botanist of this Institute, was able to complete the checking up of the nomenclature. This made it impossible for us to incorporate all the information in appropriate places in the book. We have, therefore, given in appendix IV of the book a list of names which have been changed by him.

CLASSIFICATION OF WOODS

Systematic classification of plants is a prerequisite to their anatomical investigation. The systematist classifies plants mainly on external morphology, while the anatomist studies their internal structure. Since this book deals with the anatomical structure of the secondary xylem or wood of Indian trees and shrubs, it would be appropriate to say here a few words on the present position of systematic classification *vis-à-vis* anatomical structure. It can in a general way be said that the taxonomic classification of woody plants is not always in agreement with the anatomical structure of their woods. Only a few families have woods which exhibit similar anatomical structure.

In some of them, every genus and every species shows exactly the same anatomy. The variation that one species is capable of producing can be traced not only in the other species belonging to the same genus but also in all the species belonging to other genera[1]. As a result, the woods belonging to the members of these families can be classified only up to the family level and not below. This happens in the families *Annonaceae* and *Magnoliaceae*. There are others like *Dipterocarpaceae*, *Ebenaceae*, *Lauraceae*, *Rubiaceae* and *Sapotaceae* which in spite of showing minor differences at generic level can be easily spotted because of some striking characters common to all the members within the family. Again, in *Apocynaceae* and *Leguminosae*, a great majority of the woods show similarity to such an extent that it is not so difficult to recognize most of the timbers belonging to these families. However, in a large number of families, the wood structure is heterogeneous.

Now coming to the next lower rank, it must be pointed out that anatomists have for a long time recognized the genus to be the best defined amongst all the graded classes made by taxonomists. Usually, different species within a genus show identical anatomical structure. But the characters used for separating different genera in a family are not the same in every case. Certain characters or combination of characters may be useful in separating the genera in one family but those very characters may not serve equally well in another family.

The delimitation of genera by the structure of their woods, however, is not always possible. For instance, in *Leguminosae* some species of *Dalbergia* and *Pterocarpus* show such variation in parenchyma distribution that sometimes it is not possible to say with certainty whether a piece of wood belongs to one or the other. Similar overlapping of generic character is also found in the family *Combretaceae*. Occasionally *Terminalia chebula* produces wood which in all anatomical details is identical with those of the different species of *Anogeissus*. Again, in *Anacardiaceae* the genera *Gluta* and *Melanorrhoea* have similar structure except for the thickness and frequency of apotracheal parenchyma bands. The glutas always have thin apotracheal bands at irregular intervals, while the melanorrhoeas have thick apotracheal bands at regular frequency, and also occasionally thin bands at irregular intervals thus making it some times difficult to separate the two genera. In addition, there are instances in which exactly similar wood structure occurs in two to three genera of the same family. This happens, in the genera *Cullenia*, *Durio* and *Neesia* of *Bombacaceae*, in *Boswellia* and *Garuga* of *Burseraceae*, and in *Aporosa* and *Hemicyclia*, *Excoecaria* and *Sapium* and *Baccaurea* and *Cleidion* of *Euphorbiaceae*.

Now we come to the next lower rank of the systematists, namely species. Classification of wood down to the species is possible only in exceptional cases,

1. K. A. Chowdhury. Dicotyledonous fossil woods; Convergent wood structure. *Proc. 8th International Botanical Congress*, 1954.

because at this level the wood structure is very homogeneous. However, it can be done, when there is a single species in a genus or when a species constantly shows a line of specialization not found in the remaining species of the genus. *Morus laevigata* is a good example of the latter case. Occasionally it may also be possible to separate the various species of a genus into two or more groups as in *Shorea*, *Quercus* and *Pinus*. It will be realized that the anatomical characters that can be used at this level are of minor nature. The size and frequency of these characters are the only basis that can be used profitably. However, not much work has been done on this aspect of wood anatomy and there is still a long way to go.

To classify the secondary xylem or the wood, it is of primary importance to understand the variation that it exhibits. This fact has no doubt been recognized by botanists for a long time and yet due attention has not always been paid to it. For instance, data collected from herbarium material of perennial plants have formed the basis for far-reaching conclusions. Descriptions of many genera have been based on the study of a single species. Anatomy of herbaceous and perennial plants has been mixed, ignoring the fact that production of the secondary xylem in herbs is often negligible, while in trees it is one of the most important functions. Leaving aside all this confusion in literature, it may be pointed out that some recent researches have thrown considerable light on the problem of variation in the secondary xylem. In the perennial dicotyledons, three types of xylem have been recognized, namely, diffuse-porous, ring-porous and semi-diffuse-porous or semi-ring-porous[1]. Some overlapping in these three types has also been observed for some years now. But from a recent study of these plants, it appears that there are three sub-groups in the diffuse-porous type. The first contains those which alway remain diffuse-porous showing little effect of the environment in which they grow such as *Acer* (*Sapindaceae*), *Cornus* (*Cornaceae*) and *Michelia* (*Magnoliaceae*). The second sub-group contains those which are usually diffuse-porous but occasionally show semi-ring-porous structure. The anatomical variation exhibited by these does not seem to have any relation with their environments. Typical examples are *Diospyros* (*Ebenaceae*), *Juglans* (*Juglandaceae*), *Swietenia* (*Meliaceae*) and *Terminalia* (*Combretaceae*). Finally, there are those which are diffuse-porous in favourable climate but turn semi-ring-porous to true ring-porous under extremely unfavourable conditions of growth, for example, *Betula* (*Betulaceae*), *Grewia* (*Tiliaceae*) and *Salix* (*Salicaceae*).

It has also been found that the true ring-porous type is not confined only to temperate climate, though it may occur more often in temperate countries than in the tropics. The well-known genera of ring-porous trees in temperate

1. K. A. Chowdhury. Secondary xylem in perennial plants. *J. Indian bot. Soc.* Presidential address, 33, 1954.

climate are *Fraxinus* (*Oleaceae*), *Quercus* (*Fagaceae*) and *Ulmus* (*Ulmaceae*), while in tropical climate they are *Tectona* (*Verbenaceae*) and *Lagerstroemia* (*Lythraceae*).

The semi-diffuse-porous or semi-ring-porous type contains those which show all possible variations from the true diffuse-porous to true ring-porous structure in the one and the same tree. These variations have been found to be independent of the environmental conditions in which the trees grow. *Gmelina* (*Verbenaceae*) is the only genus in which we have come across this phenomenon.

Some progress has also been made in the understanding of the variability that occurs in the cell elements of the secondary xylem. Amongst the fibres, septate fibres have been studied in some detail at Dehra Dun[1,2]. These usually live longer than fibre-tracheids and produce septa which appear to lack secondary thickenings. In some genera, like *Protium* (*Burseraceae*) there is little effect of environment on the formation of septate fibres, while in others like *Lagerstroemia* (*Lythraceae*), the percentage of septate-fibres varies from locality to locality depending on the environments. Furthermore, the septate fibres and the crystalliferous fibres are interrelated. Some septate fibres develop crystals in the later stage of their life and form the crystalliferous fibres.

The variability of structure produced by the parenchyma cells is very complicated and at present far from clearly understood. A few years ago, an attempt was made to roughly classify the apotracheal parenchyma[3]. Further investigation shows that some genera exhibit considerable variation in the thickness of their apotracheal bands, while others vary only slightly or not at all.[6] In the genus *Ficus* (*Moraceae*), the thickness of the apotracheal band varies from 6 to 13 cells and is somewhat related to the rate of growth, while in *Kydia* (*Malvaceae*), the band is made up of mostly 2 cells and shows no relation to the width of the growth ring. A clear picture is now also available of the role that the initial parenchyma cells play in the transformation of diffuse-porous-woods into ring-porous woods.

As regards the remaining elements, we are still in darkness as to how the variation works in them. However, the study of variation in the secondary xylem and its cell elements so far made has brought out three important points. Firstly, in some genera variation is caused by a change in the environmental conditions, while in others no such effect occurs. Secondly, all the cell elements of secondary xylem are not equally affected by environment. In this respect,

1. S. K. Purkayastha. A contribution on the development of septate and crystalliferous fibres in some Indian forest trees. *Proc. 40th Ind. Sc. Cong.* Part III, Abstract, 1952.

2. K. A. Chowdhury, S. K. Purkayastha, S. S. Ghosh and J. S. Sond. Septate fibres in Angiosperms and their length. *Nature* 177, pp. 1243–44, 1956.

3. K. A. Chowdhury and S. S. Ghosh. On the anatomy of *Cynometroxylon indicum* Gen. Et. Sp. Nov.; A fossil dicotyledonous wood from Nallalang, Assam, *Proc. Nat. Inst. Sci. India*, 12, 1946.

each element appears to be controlled by its inherent characteristics. Thirdly, there are some risks in classifying mature tissues and elements without a knowledge of the different stages of their development from inception to maturity.

CONVERGENT WOOD STRUCTURE – PARALLEL DEVELOPMENT

For some time now, mention has been made in botanical literature on the convergent wood structure, but actually many people are not clear in their minds as to what it means. The subject has been discussed in some detail at a symposium of the last International Botanical Congress held in Paris[1]. The results are summarized below :—

First of all the pertinent question is what is meant by convergent wood structure. Does it mean existence of identical anatomical structure in the woods of different species in a genus or in the woods of different genera in a family or in the woods of different families in an order ? Again, do the woods of different families and genera show exactly the same anatomical structure ? From what has already been said, it will be seen that at species level convergent wood structure is usually present. All genera show homogeneous wood structure except a few. Sometimes similar structure may also be found in the members of two closely related genera belonging to the same family. There are also a few orders which show a great deal of general similarity in gross structure. Now as to the convergent wood structure in the woods of unrelated families and genera, there may be a few but we have not so far come across any case in which two woods belonging to different families have shown identical structure in all macroscopic and microscopic details.

The inability of the anatomists to separate most species and some genera fixed by the taxonomists raises a fundamental point on the rate of evolution in living perennials. Do all organs of a plant show a synchronized evolution ? Researches carried out by the anatomists for the last fifty years have shown that the rate of evolution in the external morphology and the internal anatomy is different. Not only is this true but there is also sufficient data to draw the conclusion that very little synchronized evolution can be traced in different elements of a tissue in an organ.

Secondly, frequent parallel development of tissues and cell elements in the woods of closely and distantly related genera, is to a great extent responsible for the impression that there is convergent wood structure. For instance, the ring-porous structure has been developed in many families, all of which cannot be said to be closely related. Often in a family only a genus or two may show ring-porousness and the rest may not as in *Moraceae*. Here it is interesting to note that the regularity of variation in the formation of ring-porousness in the woods of different genera and families, is very striking. Again, the rays of

1. K. A. Chowdhury. Dicotyledonous fossil woods; Convergent wood structure. *Proc. 8th International Botanical Congress*, Paris, 1954.

Rubiaceae and those of *Apocynaceae* and *Icacinaceae* show parallel development in the distantly related families. Many other examples of parallel development have been given by Metcalfe and Chalk in their book "Anatomy of the Dicotyledons". They have shown woods of many different families under scalariform perforation plates, spiral thickenings, septate fibres, radial gum canals, etc. Incidentally, the phenomenon of parallel development and variation is not anything new but has been known to botanists for more than last one hundred years.

Thus it will be seen the present confusion over the classification of the woods of perennial plants is not so much due to the development of convergent structure as to the lack of understanding of the complicated nature of these woods.

All that has been discussed above is of fundamental nature and should form the basis for utilizing the anatomical information given here for practical purposes. The method of collection and presentation of the data in this book needs to be explained at this stage. First of all, each wood specimen was studied with the help of a microscope. For this purposes, thin sections had to be cut with microtome and then stained according to various methods. The anatomical features observed under the microscope were analysed with a view to utilizing only those which could be detected by naked eye or with the help of a hand lens magnifying 10–12 times. Thus it will be seen that all the anatomical descriptions given in the book are confined to those that can be seen with the naked eye or with a hand lens.

INFORMATION UNDER THE FAMILY

Each family begins with the information on the number of genera and species that it contains. If there is any difference of opinion on the position of the family, it is mentioned here. The distribution of the family throughout the world as well as its concentration in any particular part is also given including the habit of the members that is, the size they attain. Commercial importance of the wood in any part of the world follows with special mention of Indian species, if any. Economic importance of other products of the family is also briefly dealt with. This is followed by the number of genera found in India with particular reference to those attaining tree size. Here, a brief mention of those woody genera which are not dealt with in this book is also made including woody climbers.

A brief description of the salient features of the wood follows the general information on the family. Reference is made here to any exceptional anatomical character present in the foreign woods of the family but not in its Indian members. Any important anatomical data that have been collected by the Wood Anatomy Branch, on parts of trees other than wood, are included here. This is followed by a key to genera or groups of genera, wherever possible.

INFORMATION UNDER THE GENUS

The genera in a family are given in alphabetical order. Under each genus, the number of species in the world is given with their distribution and habit. Fossil record, if any, is mentioned here. This is followed by the distribution of the genus in India. Special mention is made of any woody species for which no authentic sample was available for study ; distribution of these species along with their local names is given for reference work. These details, it is hoped, might be helpful to those who would like to collect the little known timbers. Finally, a key to species or groups of species, where possible, is included.

INFORMATION UNDER THE SPECIES

Species are dealt with in alphabetical order. Trade names are given after the name of the species wherever available. These are printed in bold types. Local names are given in alphabetical order of the languages and the abbreviations used for them are given below. In certain cases where only the locality is known but not the local language both have been treated at par and arranged in alphabetical order.

Abbreviations	*Full name*	*Abbreviations*	*Full name*
Asm.	Assamese	Lop.	Lopcha
Beng.	Bengali	Lush.	Lushai
Bhum.	Bhumia	Mal.	Malayalam
Bhut.	Bhutia	Manip.	Manipur
Burm.	Burmese and other languages of Burma.	Mar.	Marathi
		Mik.	Mikir
Cach.	Cachar	Nep.	Nepali
Duff.	Duffla	Or.	Oriya
Garh.	Garhwal	Punj.	Punjabi
Gon.	Gondi	Sans.	Sanskrit
Guj.	Gujarati	Sant.	Santali
Hind.	Hindi	Sinh.	Sinhalese
Jauns.	Jaunsar	Sylh.	Sylhet
Kach.	Kachari	Synt.	Synteng
Kan.	Kannada (Kanarese).	Tam.	Tamil
Kash.	Kashmiri	Tel.	Telugu
Kh.	Khasi	Th.	Tharu
Kharw.	Kharwar	Tipp.	Tippera
Kol.	Koli	Urd.	Urdu.

After the local names the habit of the species is given indicating its maximum height, the shape of the crown, the height of the clear bole, the girth at breast-height and the external morphology of the bark, its colour and thickness. This information will, it is hoped, be useful not only for recognizing the timber in log form but also for estimating the cost involved in utilizing it. Information on economic products of the species other than the wood is also given where it has a direct bearing on the internal anatomy of the stem as in the case of gums, resins, oils, etc. In order to make this information useful, unpublished data of Wood Anatomy Laboratory have been freely drawn upon. The distribution of the species which is given next covers mainly India. A brief reference to neighbouring countries is also made where the information was easily available.

DESCRIPTION OF THE WOOD

The description of the wood is given separately for each species only when different species within a genus can be separated without much difficulty. When the various species of a genus are anatomically similar and cannot be differentiated, the description of the wood of all the species is given together after the general information. Here, mention has been made whenever a variation occurs in any of the species. However, where the genus can be divided into two or more groups based on anatomy, the description of wood is given separately under each group. Under description of the wood, information is given on general properties, gross structure, strength, seasoning, natural durability, susceptibility to insect and fungus attack, preservative treatment, working qualities, supply and uses and the material studied.

GENERAL PROPERTIES

These include colour of the wood - both sapwood and heartwood, hardness, specific gravity, odour, lustre, grain and texture. Explanatory notes on these properties are given below :

Colour—The colour of the outer portion of a log or sapwood is usually lighter than the inner or central portion known as heartwood. The colour distinction is not, however, present in all species. The sapwood, being subject to sapstain is often discoloured particularly in logs which are kept exposed for a long time. The colour of the heartwood varies to a great extent. The predominant colour throughout the log may be white as in gutel, *Trewia nudiflora* or black in the centre as in ebony, *Diospyros ebenum*. Again, the colour may be uneven, showing alternate, light and dark coloured bands or patches on the end surface. These timbers when carefully converted often produce beautiful figure (Pl. C, 31 ; Pl. D, 38).

Sometimes the colouring matter of the wood comes off in contact with water. In fact, before the aniline dyes came into use, the heartwood of some

species belonging to the *Leguminosae* and *Moraceae* was the source of some commercial dyes. Occasionally the water extract of such timbers shows fluorescence which may be very pronounced as in *Pterocarpus*.

However, the colour is a character which should be used with great caution for the identification of woods. Here experience counts more than any other factor. The colour not only varies from wood to wood but also in the same wood. Marked changes due to exposure are also not uncommon as in mulberry (*Morus* spp.) and toon (*Cedrela toona*). Further, due to the absence of any universally accepted standard for describing the colours of wood, there is likely to be some difference of opinion in this respect.

Hardness—The customary physical laboratory test for hardness consists of finding the resistance which wood offers to indentation. However, in all our descriptions hardness has been estimated from the resistance offered by the wood when cut by a sharp knife across the grain.

Weight—This is based on the specific gravity determined by the Wood Anatomy laboratory. According to the usual practice at this Institute, the Timber Mechanics Branch supplies the specific gravity and weight of wood to all other branches when required. In this case a deviation had to be made. The data on specific gravity at present available in the Timber Mechanics Branch are confined to some 300 species only, whereas, the number of species for which specific gravity is required for the writing up of the book is 1600. Since the Wood Anatomy Branch had to find out specific gravity of the remaining 1300 species by a method in which a single standard size of the wood specimen could not possibly be used, it was thought advisable to determine the specific gravity by a well-known method for all the 1600 species. The details of the method are given below. Here, it may be pointed out that the data on specific gravity for 300 species collected by the Timber Mechanics Branch have been incorporated in Appendix I along with other test figures.

The method used for determining specific gravity is the one given by L. N. Seaman in his publication, "Mechanical, physical and structural properties of wood grown in India". In this method, the wood sample is weighed to the nearest 0·10 gm. For finding out the volume, a receptacle filled with sufficient quantity of water is weighed both with and without the specimen. The specimen is completely immersed in water with the help of a needle and kept in position by a clamp. Care is taken not to allow the specimen to come directly in contact with any part of the receptacle. The difference between these two weights gives the weight of water displaced by the sample. Finally the specific gravity is determined by dividing the weight of the wood sample by the weight of the water it has displaced.

One of the defects of this method is that the air-dry sample absorbs water when immersed. To minimize this, two precautionary measures are

taken. Firstly, the specimen is dipped in water before it is immersed in the vessel or receptacle. Secondly, the weighing is done as quickly as possible. It is realized that the method is not perfect, especially in the case of the light and coarse-textured woods which absorb water quickly. Nevertheless for the types of specimens at our disposal, it has been considered to be most suitable.

It is customary in a book like this to classify woods based on their weight. There are many different classifications of Indian woods by different workers. After giving full consideration to all the existing classifications, the following has been drawn up for this book :—

Class	*Specific gravity*
Very light (Papita class)	... Less than ·35 (below 21·84 lb. per cu. ft.)
Light (Semul class)	... ·35–·55 (21·84 to 34·32 lb. per cu. ft.)
Moderately heavy (Teak class)	... ·55–·75 (34·32 to 46·8 lb. per cu. ft.)
Heavy (Sal class)	... ·75–·95 (46·8 to 59·28 lb. per cu. ft.)
Very heavy (Sundri class)	... More than ·95 (above 59·28 lb. per cu. ft.)

Lustre—It is well known that some woods like chickrassy (*Chukrasia tabularis*), kokko (*Albizzia lebbeck*), poon (*Calophyllum* spp.) and satinwood (*Chloroxylon swietenia*) show characteristic lustre or sheen. This is due to a special physical property of cell walls which reflect light. All woods, however, do not have this property. When present, it is of considerable value from aesthetic point of view and can be also utilized as a diagnostic feature of the wood.

Odour—All freshly cut timbers left in the forest for some time give off an odour. This is due to the fermentation of carbohydrates deposited in the cell cavities and is, therefore, of no diagnostic value and has nothing to do with the characteristic odour peculiar to some timbers. However, some timbers like deodar (*Cedrus deodara*), sandalwood (*Santalum album*) and teak (*Tectona grandis*) have characteristic odour which is very useful in identification. The odour in such cases is mainly due to resins, oils, and other chemical deposits.

Grain and texture—These terms are often carelessly used causing considerable confusion. Grain relates to alignment of cells, that is, whether they are straight or twisted in relation to the axis of the tree. Texture applies to size and distribution of cell elements in a unit volume. Usually coarse-textured woods like gurjan (*Dipterocarpus* spp.) and semul (*Salmalia malabarica*) are rough on the surface after conversion. On the other hand, in woods like axlewood (*Anogeissus latifolia*), haldu (*Adina cordifolia*) and sandalwood (*Santalum album*), the texture is fine giving a smooth feel. Apart from identification, these two properties are of considerable value to timber users. Much depends on the grain and texture of a wood as to whether it will produce

a beautiful figure on the panels or not and whether it can be given an excellent polish or finish.

Figure in wood—Usually timbers show some markings or designs on the longitudinal surface after conversion which are known as figure. But only a few of them have figure of sufficient beauty to be of decorative value. Such figured timbers are exploited with advantage by the high class cabinet and furniture makers. Figure in wood is caused by anatomical and other features such as growth rings, the nature of the grain, conspicuous rays, parenchyma pattern and chemical deposits that the cells contain. The last factor plays a much more important part in tropical woods than in temperate ones. It is not so much the amount of chemical deposits but the variation of deposits in different types of cells and tissues, that is important for the production of beautiful figure. With experience in conversion of timber, backed by a knowledge of the anatomy of wood concerned, one can take advantage of all the factors and bring out figure not only in planks but also in veneers. Typical examples of figure in Indian woods as seen on the longitudinal surfaces are illustrated in plates C and D (figs. 29–40). In chickrassy, *Chukrasia tabularis* (fig. 29) the figure is due to chemical deposits in alternate layers and the ray-flecks, while in laurel, *Terminalia tomentosa* (fig. 31) and sissoo, *Dalbergia sissoo* (fig. 38), it is caused by growth marks and variation in deposits. The occurrence of deposits in jet-black bands or irregular patches in Andaman marble wood, *Diospyros marmorata* is responsible for producing a highly ornamental type of figure. Poon, *Calophyllum inophyllum* (fig. 33), makai, *Shorea assamica* (fig. 34) show the characteristic ribbon or stripe figure resulting from interlocked-grain. In the case of mango, *Mangifera indica* (fig. 36), and kokko, *Albizzia lebbeck* the striped figure may be modified to give a quilted appearance due to wavy alignment of fibres. A typical example of the effect of curly grain traceable to minute undulation in the direction of fibre arrangement is shown by mahua, *Madhuca latifolia* (fig. 40). Figure due to growth rings is more common in non-porous and ring-porous woods than diffuse-porous woods and is seen to best advantage on the tangential surface of board face. Chir, *Pinus roxburghii* (fig. 39) and elm, *Ulmus wallichiana* (fig. 37) are good examples. Some timbers like oak (*Quercus* spp.), and *Carallia lucida* (fig. 32) have large and conspicuous rays which show as prominent flecks on the quarter-sawn boards exhibiting what is commonly known in the trade as silver grain. The presence of broad, alternating layers of parenchyma and fibres gives rise to a beautiful type of figure called partridge mottling which may be often seen in timbers like silver grey wood, *Terminalia bialata* and *Cassia fistula* (fig. 35). An exceptionally beautiful type of figure known as burr or burl is produced in abnormal type of wood found in wart-like excrescences of the trunk or a large branch as in Andaman padauk, *Pterocarpus dalbergioides* (fig. 30), and walnut, *Juglans regia*.

GROSS STRUCTURE

For a clear understanding of what part of a plant constitutes wood, one must refer to some standard books on botany and especially on plant anatomy. It will suffice to say here that the secondary xylem of the perennial plants is known as wood. The woods dealt with in this book come from both conifers and broad leaved trees. Anatomically wood is composed of minute tube-like cells whose size and shape vary considerably. Two main groups of timber are recognized namely non-porous (Pl. A, 1 and 2) and porous. Again, the porous type has been divided into two sub-groups namely, ring-porous (Pl. A, 3) and diffuse-porous. These classifications are based on the presence or absence of pores or vessels and again when pores are present, on the pattern of their distribution. The non-porous and ring-porous woods usually exhibit clear growth marks indicating the layers of wood that are laid down by a tree in a growth season. Demarcation of these marks is due to the difference in the tissues that are formed during the early and the late part of the growth season. The tissues that are laid down during the early part of the season, are known as early wood, and those that are laid in the later part of the season, as late wood.

Growth rings—The greater the difference between the late wood and the early wood, the more prominent is the growth ring. In non-porous woods only the marked difference in the size, shape and cell wall thickness of the early and the late wood tracheids produces the growth ring as in deodar (*Cedrus deodara*), and chir (*Pinus roxburghii*).

In porous wood on the other hand, the anatomical structures responsible for true growth ring are many and some of them are given below.

(*a*) Ring-porous characters as in teak (*Tectona grandis*), jarul (*Lagerstroemia flos-reginae*), mulberry (*Morus alba*) and persian lilac (*Melia azedarach*).

(*b*) Semi-ring-porous characters as in toon (*Cedrela toona*), walnut (*Juglans regia*), bola (*Morus laevigata*), bijasal (*Pterocarpus marsupium*), and Andaman padauk (*Pterocarpus dalbergioides*).

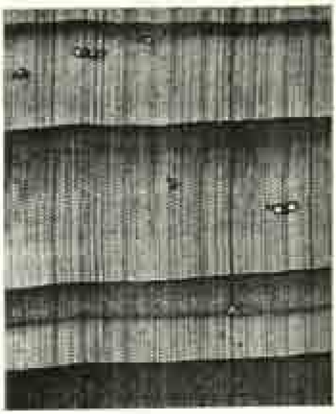
(*c*) Initial parenchyma as in laurel (*Terminalia tomentosa*), mahogany (*Swietenia macrophylla*), satinwood (*Chloroxylon swietenia*).

(*d*) Terminal parenchyma as in magnolia (*Magnolia campbellii*), champ (*Michelia champaca*).

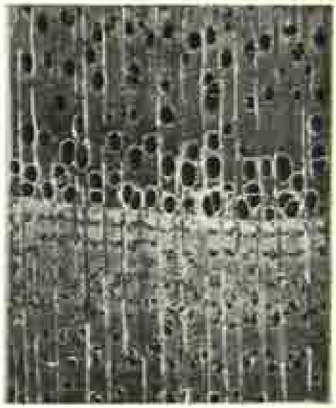
(*e*) Difference in size, shape, arrangment and cell-wall thickness of the early and late wood fibres as in thitka (*Pentace burmanica*), kusum (*Schleichera trijuga*), *Grewia* spp., *Albizzia* spp., *Anogeissus* spp., and sandalwood (*Santalum album*).

(*f*) Difference in size and frequency of vessels in early and late wood as in *Mansonia dipikae*, *Boswellia serrata* and many others.

1. Abies pindrow



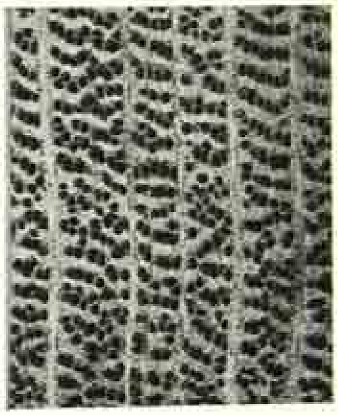
2. Picea smithiana



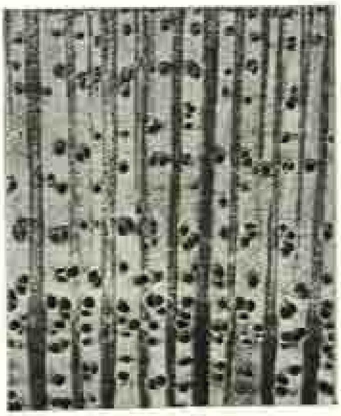
3. Morus indica

4. Xanthophyllum flavescens

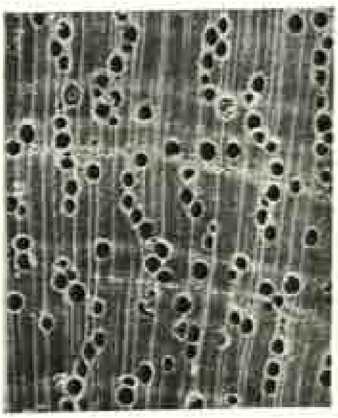
5. Sideroxylon longepetiolatum



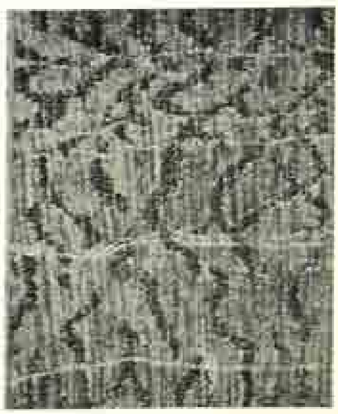
6. Stemonurus sp.



7. Tamarix articulata



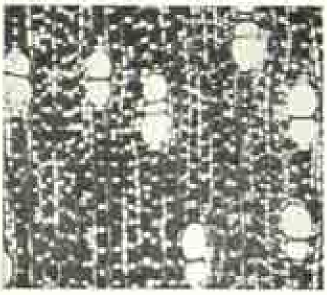
8. Calophyllum tomentosum



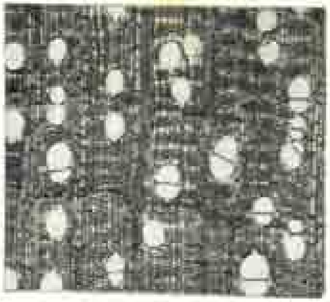
9. Osmanthus suavis

1-2, Non-porous woods: 1, without resin canals; 2, with resin canals. 3-9, Porous woods, vessel distribution: 3, ring-porous; 4, solitary; 5, radial multiples; 6, tangential multiples; 7, clusters; 8, radially oblique chains; 9, flame-like. (All ×10.)

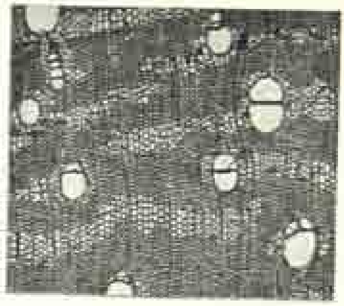
Plate B



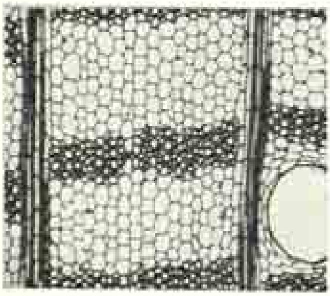
10. Cyclostemon confertiflorus



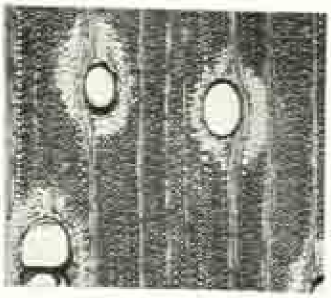
11. Sageraea elliptica



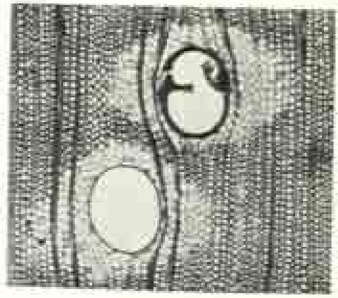
12. Erioglossum rubiginosum



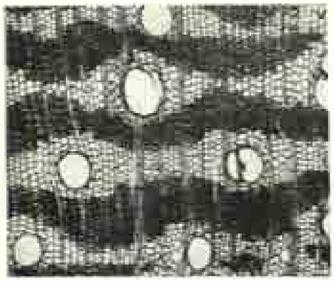
13. Erythrina suberosa



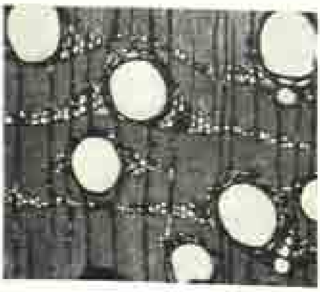
14. Acacia catechu



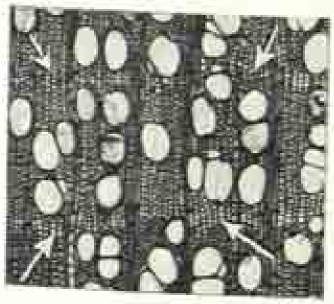
15. Albizzia lebbeck



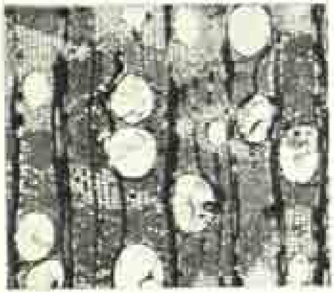
16. Ougeinia dalbergioides



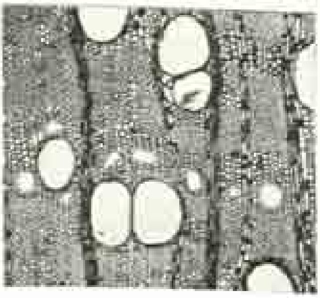
17. Terminalia tomentosa



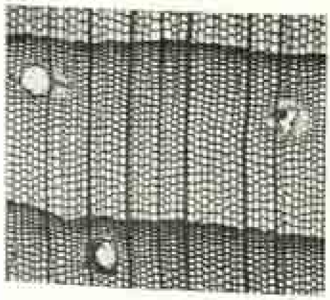
18. Michelia champaca



19. Dipterocarpus tuberculatus



20. Parashorea stellata



21. Pinus gerardiana

10–18, Parenchyma distribution: 10, diffuse; 11, net-like; 12, broken wavy bands; 13, banded; 14, vasicentric; 15, aliform; 16, confluent; 17, initial; 18, terminal. 19–20, Gum ducts: 19, solitary or small groups; 20, concentric band. 21, Resin canals, irregularly distributed. (All × 30.)

The width of the growth rings varies in different species and even in the same species. The rate of growth is controlled by the genetical make-up of the tree and the environmental conditions in which it grows. What is considered to be fast growth in one species may not be sc in another. From practical point of view, it can, however, be said that too fast and too slow grown timbers are likely to be weak.

It has been known for a long time that slow grown non-porous woods are usually strong. The reason for this has been found to be that the volume of late wood, in this group of timbers, remains more or less constant irrespective of the width of the ring. More the number of growth rings per centimetre, higher is the precentage of late wood and stronger the timber. But experience has also shown that this is not always true. Some slow grown non-porous timbers are unexpectedly weak. Anatomical investigation of these timbers has revealed that the voulme of late wood remains constant only up to a certain number of rings per centimetre beyond which its volume also decreases along with the reduction in the width of the ring. In Indian spruce, *Picea smithiana*, we have found out that the strongest timber is produced when the rings vary from 7–16 per inch (approximately 3–6 per cm.) and that the spruce wood with less than 7 and more than 16 rings per inch is likely to be weak.

In the ring-porous timber, it is just the other way. Faster the growth, stronger is the timber. In this case, the volume of early wood remains more or less constant irrespective of the width of the ring. But once again we find that too fast grown ring-porous timbers are also weak. This is due to the fact that the cell-wall of the late wood becomes unusually thin as a result of fast growth. In the ring-porous wood of teak (*Tectona grandis*) the strogest timber has so far been found to be with growth rings varying from approximately 4–12 per inch (about 2–5 per cm.). It is doubtful whether teak wood with less than 3 rings per inch will serve any purpose for which strength is considered to be the main criterion. On the other hand, it is a common experience that extremely slow grown teak plank will break under the pressure of fingers like a piece of biscuit[1].

Now, in the third group of woods namely diffuse-porous, the rate of growth may or may not have any relation with strength. The difficulty in this group is that growth rings are not always well marked due to the absence of well-defined early and late wood. The variation in the amount and distribution of different tissues brought about by a change in the rate of growth is also not yet clearly understood. The problem is a very complicated one and will take a long time to solve. However, some preliminary investigation[2] done at Dehra Dun shows that the effect of rate of growth in diffuse-porous hard woods is not

1. K. A. Chowdhury. Some aspects of pure and applied botany, *Proc. 35th Ind. Sc. Cong.* Part II, Presidential address, 1948.

2. S. S. Ghosh, K. Ramesh Rao and S. K. Purkayastha. Variation in structure and quality of some Indian woods in relation to growth, *Proc. of the 7th British Commonwealth Forestry Conference*, Australia, 1957.

the same in all species. Some timbers like *Anogeissus* spp., *Aegle marmelos*, *Chloroxylon swietenia* and *Carallia integerrima* do not show much variation in specific gravity due to the changes in the rate of growth. But there are other species which give an entirely different picture. For instance, in *Salmalia malabrica* and *Sterculia campanulata*, fast growth is associated with a low specific gravity due to less quantity of cell-wall material per unit volume. From anatomical point of view this is brought about by increase in parenchyma and ray volume, and decrease in fibre wall thickness. The timber consequently becomes weak. Again in some timbers like laurel (*Terminalia tomentosa*) and champ (*Michelia champaca*) extreme slow growth produces spongy and weak timber mainly due to increase in pore volume.

Mention may be made here of the anatomical structures which sometime give the impression of growth rings but are not actually so. False growth rings found in non-porous woods like chir (*Pinus roxburghii*), fir (*Abies pindrow*) and spruce (*Picea smithiana*) are due to the presence of thick-walled tracheids in the middle of growth ring. Similarly in the case of ring-porous or semi-ring-porous woods like teak (*Tectona grandis*) and toon (*Cedrela toona*), a change in the thickness of the fibre walls produces false rings. Further, some members of the *Dipterocarpaceae* like *Shorea* and *Hopea* and those of *Meliaceae* like toon (*Cedrela toona*) and white cedar (*Dysoxylum malabaricum*) show concentric rows of gum ducts which give the impression of growth rings but actually have nothing to do with the true growth marks. Occasionally gelatinous fibres develop in concentric tracts in the woods of some families like *Anacardiaceae Lauraceae*, *Leguminosae*, etc., giving the impression of growth marks (Pl. C, 27).

Vessels or pores—In porous-woods, the pattern of distribution of pores is often characteristic and is, therefore, taken advantage of for the purpose of classification and identification. The ring-porous structure is due to the concentration of large pores at the early part of the growth ring, and the late pores are usually much smaller in size than the early pores as in mulberry, *Morus indica* (Pl. A, 3). In most woods, the pores are either single or in multiples in one and the same timber. There are, however, a few woods in which pores are exclusively or predominantly solitary as in *Xanthophyllum flavescens* (Pl. A, 4). The way the pore-multiples are distributed makes it easy to classify certain timbers. In *Sideroxylon longepetiolatum*, the pores are in radial multiples, while in *Stemonurus* spp. they are in tangential multiples (Pl. A, 5 and 6). Again, the distribution of pores sometimes is not strictly speaking in multiples but in clusters. Here a bunch of pores of small size are packed up together as seen in *Tamarix articulata* (Pl. A, 7). Some diffuse-porous woods show a radially oblique arrangement of pores which is typical of *Calophyllum* spp., *Mesua ferrea* and *Quercus* spp. (Pl. A, 8). Some of these structures may not always be characteristic of a genus or a species but with experience one can profitably use the distribution of pores for classification and identification. There is

another type of distribution which can also be used with profit. In this the small pores are found in clusters which show a tendency for oblique distribution. As a result, the entire vessel distribution gives the impression of a flame-like structure. This is best seen in the woods of *Osmanthus suavis* (Pl. A, 9), *Rhamnus virgatus* and *Skimmia laureola*.

The size of the pores as seen on the end surface is also of value in classification. Since the actual measurement of the size of the pores is not always possible in the field, we have made a classification from practical point of view as given below :—

1. Very large to large	... Outlines distinctly visible to the eye.
2. Moderately large	... Visible to the eye, but outlines not distinctly visible.
3. Small to very small	... Not visible to the eye.

Apart from size and patterns of pores, formed on the end surface of the wood, their frequency is also of importance. Frequency was determined by the method given in Bulletin No. 25 of the Forest Products Laboratory, Princes Risborough, England. As to the translation of observations into descriptive terms we have used the classification made by Chattaway.[1]

Classification of pores per unit area

Very few	... up to 2 per $mm.^2$
Few	... 2–5 ,, ,,
Moderately few	... 5–10 ,, ,,
Moderately numerous	... 10–20 ,, ,,
Numerous	... 20–40 ,, ,,
Very numerous	... over 40 ,, ,,

Depending on their size, the pores are usually visible on the end surface as holes. The outline of the pores varies from round to oval in many timbers but in some it is characteristically either round or oval. In the latter case, the structure becomes valuable for classification. As a rule, vessels or pores in the sapwood are open, while in the heartwood they may either remain open or become occluded by deposits or tyloses. The deposits consist of various kinds of infiltration products and may range in colour from chalky white as in kanju (*Holoptelea integrifolia*) to dark reddish-brown in timbers like sundri (*Heretiera* spp.) and mahogany (*Swietenia* spp.). Occasionally the deposits may form as much as 25 to 30 per cent by weight of the wood as in red cutch (*Acacia chundra*). Tyloses are in-growths from the surrounding parenchyma cells into the vessel cavity and may completely block the vessels as foam-like

1. M. M. Chattaway. Proposed standards for numerical values used in describing woods, *Trop. woods* 29, 20–28, 1932.

mass in some timbers. When tyloses are abundantly developed as in sal (*Shorea robusta*), jhingan (*Lannea grandis*) and gamari (*Gmelina arborea*), they constitute a striking feature of diagnostic value. When pores are large they show up on the longitudinal surface as grooves along the grain which are known as vessel lines. The perforation between two contiguous vessel members may be simple or ladder-like. The latter is described as scalariform and may some times be seen clearly on the longitudinal surface of the timber under hand lens as in *Meliosma* spp. (Pl. C, 25) and some woods of the *Magnoliaceae*.

Parenchyma or soft tissues—The parenchyma cells are usually of a lighter colour than the fibres which form the bulk of the wood and are therefore seen distinctly on the end surface. They are distributed in many ways and the pattern they form can be conveniently used for the classification of woods. At present, there is considerable confusion in literature as to the way they are to be grouped. For a clear understanding of the terms used in this book it would be desirable to define them here.

Four main types of parenchyma distribution under hand lens can be recognized, namely (*i*) initial or terminal, (*ii*) apotracheal, (*iii*) paratracheal and (*iv*) banded. These are briefly described below.

Initial or terminal—In this type, parenchyma is visible under the lens as fine or somewhat thick lines delimiting the growth rings. They are termed *initial*[1] when laid down in the beginning of the growth season as in all ring-porous and some diffuse-porous woods like laurel, *Terminalia tomentosa* (Pl. B, 17). Their presence in diffuse-porous wood has been found to be much more frequent than at first thought. In fact in many families like *Meliaceae* and *Rutaceae* the concentric bands that occur at regular intervals are mostly of initial parenchyma cells. The term *terminal* parenchyma is applied to those cells which occur as the last tissues in a growth ring as in champ, *Michelia champaca* (Pl. B, 18). Researches carried out for the last twenty-five years on living trees have brought to light only a few trees which are in the habit of producing this type of parenchyma distribution. In fact we have so far found it in only one family namely, *Magnoliaceae*. Nevertheless, in many books on wood anatomy only the terminal parenchyma is found because it has been in use for a long time.

Apotracheal—When parenchyma cells are distributed in such a way that the pattern formed appears to be typically independent of the vessels or pores, they are called apotracheal. There are many sub-divisions in this group. When apotracheal parenchyma cells are irregularly distributed among fibres singly or in a group of 2–3 cells, they are called *diffuse*. In some timbers like *Dillenia* spp. and *Schima wallichii*, the cells are mostly single, while they are

1. K. A. Chowdhury. Terminal and initial parenchyma cells in the wood of *Terminalia tomentosa* W. & A., *New Phytologist* 34. 4, 1936.

mainly in groups of 2–3 in others as in *Cyclostemon confertiflorus* (Pl. B, 10). Parenchyma pattern is said to be *diffuse-aggregate* when the soft-tissues are for the most part in short broken tangential lines of 3–5 cells as in *Xanthophylum flavescens* (Pl. A, 4), haldu (*Adina cordifolia*) and kuthan (*Hymenodictyon excelsum*). These types often merge with the next type known as *reticulate* in which fine tangential lines run from ray to ray forming a net-like structure as in the woods of *Annonaceae* (Pl. B, 11), *Bombacaceae*, and *Malvaceae*. From the definitions of these sub-groups it must not be thought that different timbers show clearly different patterns and the classification, therefore, is easy. This is not the case. In fact, many timbers show more than one pattern of this sub-group. For instance in semul (*Salmalia malabarica*), though the predominant pattern is reticulate, it may often be diffuse-aggregate. However, there are some other woods like walnut and those belonging to *Annonaceae*, where the reticulate pattern is always a constant feature and does not merge with other types. Sometimes frequency of these apotracheal lines may be useful in identification. Again, some genera show characteristically thick apotracheal bands which end abruptly and are often described as broken apotracheal bands. *Calophyllum* (Pl. A, 8) of *Guttiferae* and *Gluta* and *Melanorrhoea* of *Anacardiaceae* are well-known examples for this type of distribution. In some timbers, however, such bands may be more or less continuous as in banati (*Lophopetalum* spp.) and chatian (*Alstonia scholaris*).

Paratracheal—When parenchyma cells are associated with the vessels or pores, they are called paratracheal. Like the apotracheal, the paratracheal also shows many patterns. When parenchyma cells form a complete sheath round a vessel or a vessel-multiple as in khair, *Acacia catechu* (Pl. B, 14), they are termed as *vasicentric*. The term *aliform* or *eye-let* is applied where paratracheal parenchyma forms wing-like lateral extensions as in kokko, *Albizzia lebbeck* (Pl. B, 15). Another characteristic type is *confluent* parenchyma. In this the coalesced aliform parenchyma cells form irregular tangential or diagonal bands as in sandan, *Ougeinia dalbergioides* (Pl. B, 16). The confluent bands may be continuous or discontinuous. When discontinuous, the structure is often called broken wavy bands as in *Erioglossum rubiginosum* (Pl. B, 12).

Banded—In this pattern concentric layers of bands of parenchyma and fibres alternate at more or less regular intervals. When the position of the vessels in relation to the parenchyma bands is clear and distinct, there is no difficulty in describing the structure as apotracheal banded or paratracheal banded. But there are many in which it is extremely difficult to say with certainty whether the pattern is mainly apotracheal or paratracheal. In such cases the bands may be more or less of the same thickness as, or appreciably wider than the intervening fibre layers. Some typical examples of the former are *Ficus* spp., *Bauhinia* spp. and *Cynometra* spp. while the latter is well illustrated by *Pongamia glabra*, and *Erythrina suberosa* (Pl. B, 13).

Rays—The width, frequency and appearance of rays are often of considerable diagnostic value but it is not always an easy task to classify rays as seen on the end surface. In this book the following classification is adopted.

1.	Very broad to broad	... Prominent to the eye.
2.	Moderately broad	... Distinctly visible to the eye.
3.	Fine to very fine	... Not visible or just visible to the eye.

As regards frequency only two classes are recognized in this book. Rays are said to be widely spaced when they are less than 5 per mm.* and closely spaced when more than 9. In between these classes a large number of woods fall and they are described as "fairly closely spaced", "not closely spaced" or "somewhat widely spaced".

Visibility of rays is not always the same in all woods. When the rays contain darkish chemical deposits along with the adjoining tissues, they do not show up clearly. In that case, the determination of their width, becomes difficult. Special care should, therefore, be taken to examine the ray tissues on the end surface. If in doubt, one must examine the tangential surfaces as this helps to get better picture of the rays. Some woods have very high rays which show up prominently on the radial surface producing conspicuous ray-flecks and silver grain.

Pith-flecks—As a result of injury by insects, certain trees develop irregular patches of abnormal parenchymatous tissues embedded in the wood. These are known as pith-flecks. Often these show up rather conspicuously against the natural colour of the wood and on board face may be mistaken for resin canals. Although one cannot identify a timber merely by the pith-flecks yet their presence is of some diagnostic value, for some woods like *Mesua ferrea*, and others belonging to family *Lauraceae* are more liable to form pith-flecks.

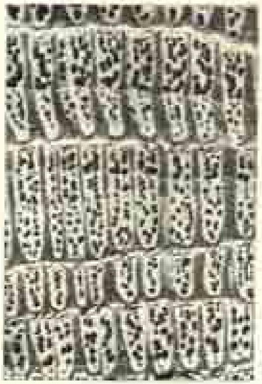
INTERCELLULAR CANALS OR DUCTS

Intercellular Canals or Ducts—Many plants are known to have secretory cells or tissues in their organs. Sometimes the secretory cells may occur in the secondary xylem. In some coniferous woods like pine and spruce the resin canals are a constant feature. They are distributed both vertically and radially in the same wood. The distribution of the vertical resin canals is often characteristic of some genera and species and can, therefore, be utilized for their diagnosis. These are of two types – (*i*) scattered and irregularly distributed as in spruce (Pl. A, 2) and pine (Pl. B, 21) ; and (*ii*) in long tangential rows at irregular intervals as in deodar (*Cedrus deodara*). In spruce, the resin canals are very few and minute and may often be overlooked even under hand lens. On the other hand in some pines the resin canals being large, show up very prominently and may give the impression of pores and vessel lines. However with

*Counted according to the scale given in the Forest Products Research Laboratory, Princes Risborough, Bulletin No. 25, 1952.

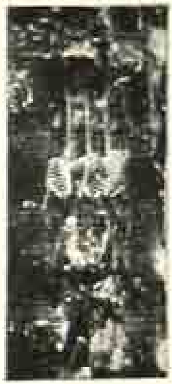
Plate C

22. Aquilaria agallocha



23. Cocculus laurifolius

24. Avicennia alba



25. Meliosma thomsoni

26. Mansonia dipikae

27. Mangifera indica

28. Picea smithiana

29. Chukrasia tabularis

30. Pterocarpus dalbergioides

31. Terminalia tomentosa

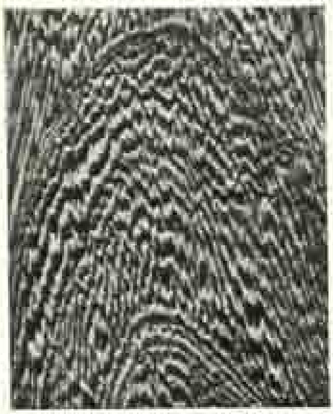
22–24. Included phloem: 22, foraminate type; 23, concentric; 24, wavy and anastomosing (×10). 25, Scalariform perforation plate (×20). 26, Ripple marks (×3). 27, Tension wood. 28, Compression wood. 29–31, Figure in wood: 29, due to rays and deposits; 30, burr; 31, growth marks and variation in deposits. (All nat. size.)

Plate D

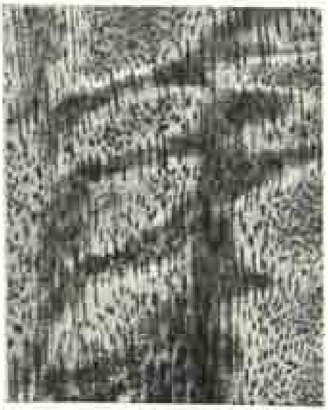
32. Carallia lucida

33. Calophyllum inophyllum

34. Shorea assamica



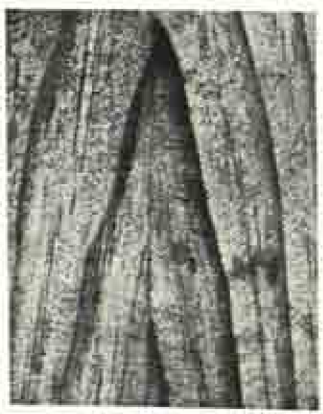
35. Cassia fistula



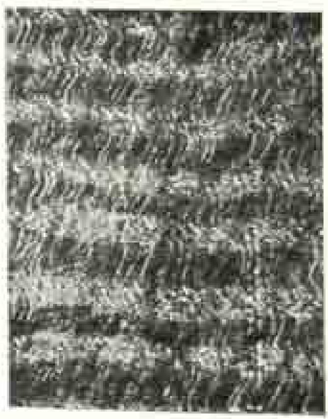
36. Mangifera indica

37. Ulmus wallichiana

38. Dalbergia sissoo



39. Pinus roxburghii



40. Madhuca latifolia

Figure in wood: 32, due to large rays; 33, 34 and 36, interlocked grain; 35, parenchyma; 37, ring-porous structure; 38, growth rings and deposits; 39, growth rings and resin streaks; 40, curly grain. (All nat. size.)

a little practice one should be able to easily distinguish the non-porous woods with large resin canals from the porous woods. The radial resin canals of coniferous woods are generally very minute and as such are distinct only under the microscope.

Some porous woods also have gum canals or ducts. Here also two types are known to occur. The vertical types are grouped under two classes namely, single or short tangential groups or arcs as in *Dipterocarpus* spp. (Pl. B, 19), and concentric or long tangential groups as in *Shorea robusta* and *Parashorea stellata* (Pl. B, 20). Only two families are known to have single or short tangential groups namely, *Dipterocarpaceae* and *Leguminosae*. In the former, it is a common feature while in the latter it occurs only occasionally as in *Hardwickia pinnata*. Long tangential groups are found in many families like *Dipterocarpaceae*, *Meliaceae*, *Rutaceae*, *Combretaceae*, *Hamamelidaceae* and *Sterculiaceae*. These are often so prominent as to give the impression of growth marks. It is believed that this type of gum duct is traumatic and develops as a result of some injury to the cambium. The radial type as in conifers is not confined only to those timbers which have vertical types. For example, radial gum canals are found in some members of the family *Anacardiaceae*, *Burseraceae*, *Guttiferae*, *Moraceae*, etc., which do not have any vertical gum ducts. When these canals are big enough as in *Garuga pinnata*, *Spondias mangifera* and *Ochrocarpus longifolius*, they can be easily detected with a hand lens on the tangential surface and are useful in classification.

Ripple marks—In some timbers the rays and other vertical tissues and cells are arranged in stories so as to bring about, on the tangential surface, the effect of fine, equidistant, wavy lines at right angles to the grain. These are known as ripple marks (Pl. C, 26). As only some timbers show this feature, they can be easily distinguished from others. The number of marks per centimetre is usually a conservative feature of a wood and can, therefore, be utilized for its diagnosis. Some of the best examples of ripple marks are *Pterocarpus dalbergioides*, *P. marsupium*, *Holoptelea integrifolia*, *Chloroxylon swietenia* and *Mansonia depikae* (Pl. C, 26).

Included phloem—The secondary xylem discussed so far may be called normal because a great majority of the perennial plants show this type of structure, which is the product of normal cambial activity. There are, however, some in which we find anomalous structure. Here, due to some unknown reason, the cambium cuts off on the inner side of the stem some phloem tissues in addition to xylem cells. This is done with such regularity that the anomalous secondary xylem produces a pattern of structure which is more or less uniform throughout. Some authorities have classified the secondary xylem of this type into eight groups while other do not agree to it. Without making an intensive study of this abnormal xylem on living plants, it seems to us to be futile to classify at this stage such a complicated tissue. For the purpose of this book

it will be sufficient if three groups are recognized. When the strands of phloem are more or less uniformly distributed throughout the wood, the structure is called *foraminate* (Pl. C, 22). The term *concentric* is applied when alternate layers of phloem and xylem run more or less all round the stem (Pl. C, 23). The alternate layers of phloem and xylem may sometimes be connected radially or obliquely by phloem tissues and give rise to a third type known as *anastomosing* (Pl. C, 24).

Mechanical properties—The properties of wood dealt with in the appendix I of this book are confined to

(*i*) Specific gravity based on weight oven-dry and volume green.

(*ii*) Weight per cubic metre at 12 per cent moisture content in Kilograms.

(*iii*) Shrinkage per cent green to oven-dry.

- (*a*) Radial
- (*b*) Tangential
- (*c*) Volumetric

(*iv*) Static bending.

- (*a*) Modulus of rupture, kg. per cm.^{2}
- (*b*) Modulus of elasticity, kg. per cm.^{2} Both green and air-dry.

(*v*) Impact bending : Maximum height of drop of a 22·68 kg. hammer, in cm.

(*vi*) Compression parallel to grain. Maximum crushing stress, kg. per cm.^{2}

For detailed information on the method of selection and testing of wood specimens, the reader is referred to some standard text-book on Timber Mechanics. To cover all the variation that a timber is likely to have, tests for each species have been based on specimens taken from 5 trees of merchantable size.

Of the 1,600 species, the mechanical properties have so far been determined by the Timber Mechanics Branch of the Forest Research Institute for about 300. For the remaining species, strength data have been collected from other sources where available. The strength data supplied by the Timber Mechanics Branch are given in the appendix I, while the data from other sources are incorporated in the body of the book.

When information on the mechanical properties of a wood was not available, we have given the strength properties of foreign timbers of the same genus having more or less similar anatomical structure. This, we hope, will serve as an index to the possible strength properties of our timber.

Seasoning—Information on the correct method of seasoning a timber is essential for its efficient utilization. This is more so in a country like India where there is considerable shortage of timbers. The data so far collected by the Seasoning Branch of this Institute are for about 250 species and these have been incorporated in this book. Advantage of published data on foreign timbers has also been taken, where it has been thought useful. It is well-known that the presence of compression wood and tension wood in a log often causes considerable difficulty in the seasoning of planks and scantlings. Compression wood (Pl. C, 27) is found in non-porous woods and can be sometimes detected by the naked eye because of its different look from the normal wood. It always produces high and irregular longitudinal shrinkage and less shrinkage across the grain. Tension wood (Pl. C, 28) is found in woods of broad leaved trees.[1] It characteristically shrinks more longitudinally and less transversally than normal wood. Occurrence of these defects in timber has been pointed out at the appropriate places. Furthermore, under the description of wood, some anatomical information has been incorporated which is likely to be helpful for a general assessment of its seasoning properties. For instance, when tyloses are profusely present the timber usually takes a long time to season as the passage of moisture, in such cases, is usually slow. Again, when the vessels are blocked up by gums and similar deposits, the timber is rather difficult to season. Presence of gum ducts, as found in the woods of *Dipterocarpus* spp., makes the timbers refractory to seasoning. In the same manner the percentage of fibres and parenchyma cells present in a unit volume of wood, determines to a great extent its seasoning properties.

Natural durability—The information under this head has mainly been supplied by the Wood Preservation Branch, based on the records of graveyard tests made for many years at the Forest Research Institute. Some forest officers also have been good enough to supply us information on this point. Information gathered by the authors during the last 30 years on the natural durability of timber that they have come across, has been incorporated.

Insect and fungus attack—Sources of these data are mostly the published literature by Entomology and Mycology Branches of the Forest Research Institute. Judicious use has also been made of some information on timbers given in foreign literature.

Preservative treatment—It is a common experience that the sapwood of practically all timbers perishes quickly. This is due to the fungus and insect attack on the sapwood which is full of food material in the form of carbohydrates. The heartwood of some timbers is naturally durable. To overcome this drawback of sapwood, it is often treated with different preservatives.

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1. S. S. Ghosh and K. Ramesh Rao. Occurrence of tension wood and its effect on properties of some Indian timbers. *Proceedings of the 7th British Commonwealth Forestry Conference*, Australia. 1957.

Leaving a few timbers whose heartwood is naturally durable, there are many in which the heartwood also does not last very long. These are also treated with chemical preservatives to increase their durability and prolong their life in service. It may be noted here that treatability of heartwood is not always the same in all species. Some are very easily treatable with complete penetration like hollong (*Dipterocarpus macrocarpus*) and hollock (*Terminalia myriocarpa*) while in others like jhingan (*Lannea grandis*), salai (*Boswellia serrata*), sal (*shorea robusta*), bijasal (*Pterocarpus marsupium*), bishop wood (*Bischofia javanica*), and piney (*Hardwickia pinnata*), the heartwood is very refractory to treatment, penetration being practically nil. The treatability of timber is often related to the anatomical structure, particularly the extent of development of tyloses, gum, resin and other chemical deposits. Records of chemically treated timbers kept under observation for years give valuable information. This has been done at the Wood Preservation Branch of the Forest Research Institute and at present durability data on treated timbers are available for about 200 species.

Working qualities—The properties of timber that come under this heading, are usually assessed by actual test in a well-equipped wood workshop. Whatever information available in the wood workshop of this Institute has been incorporated in this book. Also the anatomical description of the wood is helpful in estimating the working qualities of such woods for which no actual test has been made. For this assessment, the size and distribution of different types of cells, their alignment, deposits, etc., can be utilized.

Supply and uses—Useful information on the availability of about 165 timbers has been given by the Indian Standards Institution publication on "Classification of commercial timbers and their zonal distribution". Trotter's "Common commercial timbers of India and their uses" also gives valuable information on this point. "Commercial timbers of India" by Pearson and Brown gives some information on supplies which is rather out-of-date. We have used our experience and discretion in using information from the last publication. In addition, "West Bengal commercial timbers" by Chowdhury gives accurate information on 26 species that grow in West Bengal. The local floras especially the latest ones like "The trees of northern Bengal" by Cowan and Cowan, "Forest Flora for Pilibhit, Oudh, Gorakhpur and Bundelkhand" by Kanjilal, "Flora of Assam" by Kanjilal and others, and "Supplement to the Botany of Bihar and Orissa" by Mooney have been consulted for any information on supply that they contain. These sources have not covered all the species dealt with in this book. For the remaining species only distribution has been given without specifically mentioning the quantities available.

Information on uses of woods has been gathered from various sources and literature both Indian and foreign. This has been supplemented by the authors'

experience in the laboratory where thousands of wood samples are received for identification and advice on uses. In addition, the Supply Department of the Government of India were kind enough to make available to us the records maintained by them during the last World War on the uses of various woods. A careful analysis of these records has given us much information of value which has been incorporated in the book.

Information thus collected is only for about 600 species. For the remaining species, hardly any information is available. However, their possible uses have been recommended here based on the general properties and the anatomical structure. The data which have been taken into consideration for determining the prospective uses are, mainly specific gravity, grain and texture, pore-size, pore-distribution, percentage of parenchyma, fibers and rays. From a study of these characters, it is possible to roughly estimate the strength properties of timbers and have some idea of their suitability for various uses. Some of our timbers suggested during the last war for tool handles were based on such studies. The suitability of timbers for turnery articles is associated with small pores, narrow rays, and scanty parenchyma. The arrangement of these elements should be very uniform throughout the wood, otherwise the timber is likely to chip off under the fine tools used for carving. *Buxus* spp. and *Gardenia* spp. are suitable for this purpose because they have all the requisite anatomical characteristics. This type of broad classification of timbers based on their anatomy has been found to be very useful during the last war, when many new or unknown timbers came into the market, whose physical properties and working qualities were not known at that time[1]. Later experience has shown that recommendations made based on such classifications were not far off the mark. This, however, does not mean that the actual test in the laboratory for determining the properties of wood is not necessary. Knowledge of anatomical structure should be used for only those timbers for which no data are available and that too cautiously.

Material—All authentic wood samples available in Indian wood collection of the Forest Research Institute have been examined for the preparation of this book. After the description of the woods the number of samples studied for each species is given. The numbers listed indicate the accession number of the samples. The locality from which the wood has been collected is given after the accession number. The specific gravity of the sample is also given within brackets. The idea behind this is to show the extent of variation in weight for each species from locality to locality. For a few samples, it was not known from where they were collected. This has been indicated by leaving a blank space in place of locality.

Bibliography—For the writing up of this book, a very large number of books and journals both Indian and foreign had to be consulted. The forest vegetation of India is mainly tropical and has much in common with that of

1. K. A. Chowdhury and S. S. Ghosh. Some more commercial timbers of India. *Indian For. Rec.* (N.S.) **4**, 3. 1946.

Malaya, Africa and South America. Information available on timbers and other products of these countries is therefore likely to be useful for proper utilization of the indigenous species. Again, on the hills of northern India, there are many genera like *Abies*, *Acer*, *Betula*, *Picea*, *Pinus*, *Quercus*, *Ulmus*, etc., which are more commonly found in the temperate zones of Europe and North America. Information available on the uses of many of these foreign timbers is therefore useful for our own species. In view of this, foreign literature has been freely drawn upon wherever necessary, particularly of South-East Asia. Books like Willis's "Dictionary of the flowering plants and ferns" and Bailey's "Manual of cultivated plants" and Lawrence's "Taxonomy of vascular plants" were useful for compiling information on the distribution of families and genera. For the information on species, the following Indian floras were constantly referred to :—

1. Plants of the Punjab by C. J. Bamber, Lahore, 1916.
2. The flora Sylvatica for southern India, 2 Vols. by R. H. Beddome, Madras, 1869–74.
3. Flora of the Aka hills by K. Biswas. *Indian For. Rec.* (N.S.) Botany **3**, 1, 1941.
4. The forest trees of Travancore by T. F. Bourdillon, Trivandrum, 1908.
5. Indian Trees by D. Brandis, London, 1921.
6. Flora of the Presidency of Bombay by T. Cook, London, 1901–1908.
7. The trees of northern Bengal by A. N. Cowan and J. M. Cowan, Calcutta, 1929.
8. Flora of the upper Gangetic Plain and of the adjacent Siwalik and sub-himalayan tracts, 3 Vols. by J. F. Duthie, Calcutta, 1903–1929.
9. The flora of the Nilgiri and Pulney hill-tops, 3 Vols., by P. F. Fyson, Madras, 1915 and 1920.
10. Flora of the Presidency of Madras by J. S. Gamble, London, 1915–1936.
11. A forest flora of Chota-Nagpur, by H. H. Haines, Calcutta, 1910.
12. Descriptive list of trees, shrubs and economic plants of the Southern circle, Central Provinces, by H. H. Haines, Allahabad, 1916.
13. The Botany of Bihar and Orissa by H. H. Haines, London, 1925.
14. List of plants of the Chittagong collectorate and hill tracts by R. L. Heinig, Calcutta, 1907.
15. The flora of British India, 7 Vols., by J. D. Hooker, London 1872–1897.
16. Descriptive list of trees and shrubs of the Eastern Circle, United Provinces by P. C. Kanjilal, Allahabad, 1925.

17. Forest flora for Pilibhit, Oudh, Gorakhpur and Bundelkhand by P. C. Kanjilal, Allahabad, 1933.
18. Flora of Assam, 5 Vols, by U. N. Kanjilal, P. C. Kanjilal, A. Das and C. Purkayastha, Shillong, 1934–40.
19. Forest flora of the Chakrata, Dehra Dun and Saharanpur forest divisions, United Provinces by U. N. Kanjilal and B. L. Gupta, Calcutta, 1928.
20. Forest flora of British Burma, 2 Vols., by S. Kurz, Calcutta, 1877.
21. Supplement to the Botany of Bihar and Orissa by H. Mooney, Ranchi, 1950.
22. Descriptive list of trees and shrubs between the Ganges and Sarda River by A. E. Osmaston, Naini Tal, 1922.
23. A forest flora for Kumaon by A. E. Osmaston, Allahabad, 1927.
24. A forest flora for the Punjab with Hazara and Delhi by R. N. Parker, Lahore, 1918.
25. A forest flora of Andaman islands by C. E. Parkinson, Simla. 1923.
26. Bengal Plants, 2 Vols., by D. Prain, Calcutta, 1903.
27. Flowering Plants of Travancore by M. Rama Rao, Trivandrum, 1914.
28. List of the more important trees, shrubs, climbers and herbs occurring in the forests of Madras Presidency with their local names by V. N. Seshagiri Rao and M. H. Krishnaswamy, Madras, 1941.
29. The trees, shrubs and woody climbers of the Bombay Presidency, by W. A. Talbot, Bombay, 1902.
30. Forest flora of the Bombay Presidency and Sind, 2 Vols., by W. A. Talbot, Poona, 1909–11.
31. Silviculture of Indian Trees, 3 Vols., by R. S. Troup, Oxford, 1921.
32. Descriptive list of trees, shrubs, climbers and economic herbs of the Northern and Berar forest circles, Central Provinces, by D. O. Witt, Allahabad, 1916.

In addition, a list of selected bibliography is given at the end of each family. For the books, the year and the place of publication are given. The names of the journals are abbreviated according to the 1950 edition of the "World list of scientific periodicals". The names of journals not included in this list are given in full.

ILLUSTRATIONS

Frontispiece is a composite photomicrograph of teak showing the minute anatomical structure as seen on all the three surfaces – cross, tangential and radial. It is hoped, this will enable readers to get a three dimensional picture of the different tissues that go to the formation of a block of wood.

A map of India showing forest cover and four plates (A, B, C and D) illustrating the different anatomical structures and various types of figure in wood are included in the introduction for easy reference. At the end of the first volume, there are 30 plates containing in all 180 photomicrographs. These show end-grain structure of timbers dealt with in this volume at a magnification of about ten and are reproduced from negative prints taken directly on bromide paper from stained sections by transmitted light. Such photomicrographs will form a regular feature of the forthcoming volumes as well.

GENERAL REMARKS

In conclusion, a few suggestions indicating the way the information given in this book can be utilized by different parties which handle wood in one form or another may not be out of place. Some practical hints on how to identify timbers with the help of this book are also desirable. By referring to the book, the forest officer will come to know about the physical properties, the working qualities and uses of the timber species that grow in his area. He may then be able to induce people to buy and make use of the timbers for which there is no demand now. The industrialist by referring to Appendix III will be able to find out which timbers are most suitable for any particular industry. If he wishes to establish a new wood based industry he may refer to the distribution of recommended species given in the body of the book and decide the locality that would be most suitable for the purpose, after giving due thought to the question of cheap transport and easy storage of the raw material. Furthermore, villagers and specially those living near forest, will find in this book much information which will be of interest to them. In every forest there are at present many small trees and large shrubs which are not normally exploited for commercial purposes. Some of these produce excellent timbers and can be utilized locally for small scale industries like match, pencil and pen-holder making, toys, etc. There is also room for improvement in the already existing village industries like manufacture of carts, agricultural implements, and tool handles. By referring to this, botanists also can get an idea of the anatomical structure of the secondary xylem of the perennial plants. The variations found within the family or the genus or the species have all been incorporated in the book. Here a warning to the palaeobotanists may not be out of place. If they try to identify fossil woods based on the macroscopic descriptions and the photomicrographs given here, they are likely to go astray. A fossil wood cannot be identified by macroscopic examination only. Minute microscopic structure must be carefully studied before a fossil wood can be named with certainty.

Above all, the book will be of help in checking and verifying the identity of wood samples when in doubt. By referring to the two indices given in each volume, one can find out where the timber has been described in the body of the book. The general properties and the gross structure can then be checked

with the timber in doubt. If there is complete agreement, the timber may be said to be correctly named. If not, it is advisable to send a small sample of the wood to the Forest Research Institute for determining its correct indentity. It is customary in a book on wood anatomy to give a key for identification. At present it is not possible because necessary data for all the species have not yet been collected. If at all possible, a key will be given in the last volume. when the anatomical study of all the species will be complete. In the meantime, the reader is advised to identify an unknown piece of timber by comparing its structure with the description of the wood and with the help of the photomicrographs, given in the book.

HINTS ON IDENTIFICATION

For gross identification of woods two things are required; a good steel knife which must be kept *very sharp*, and a lens magnifying 10-12 times. The lens can be obtained from any scientific instrument dealer. In addition to these, a small chisel and a hammer are often useful, especially when one has to identify big pieces of timber which cannot be lifted easily. A small piece can be cut off with the chisel and hammer. The sample to be examined need not be large but it must not be taken from the portion too near the pith. The procedure to examine the sample is given below :—

Make a sharp cut on the end surface of the piece to be examined. Hold the lens close to the eye and gradually bring the cut surface near till its structure is clearly visible. As a rule, moistening the surface helps to bring out the structure in detail but there are exceptions to this. Both ways should, therefore, be tried for getting the best definition. The wood should be held in such a way as to get a good light on the cut surface. In most cases, a single cut will be sufficient for satisfactory identification. A number of cuts, however, may be required in some cases to ensure observation of minute characters which may otherwise be overlooked. A little experience will enable one to judge when such extra checks are necessary

It is not always realized that for the proper utilization of any timber, the first and the most important step is to know its correct identity. However, identification of timbers is not easy in this country as we have several hundred timber species in use. The way they are handled by different agencies also adds to the difficulties of sellers and buyers. Further, there is a tendency to pass off inferior timbers under the names of well-reputed ones. As a result, there is no certainty of getting the right timber and it is likely that a totally unsuitable timber may sometimes be used. Mistakes made in this way have cost the Government and the public lakhs of rupees in the past. Therefore to avoid such losses in future, the importance of using correctly identified timber hardly needs to be emphasized.

1. DILLENIACEAE

The family *Dilleniaceae* consists of 12–17 genera and about 400 species of trees, shrubs and climbers, rarely herbs. It is confined to the tropical and subtropical regions of the world, mainly the Indo-Malayan region, Australia and America.

The family includes some ornamental plants which bear large showy flowers; a few also yield edible fruits. The hard, rough leaves of some species are locally used as substitutes for sand-paper. Several species are utilized in medicine and some for tanning hides. Many lianas like *Delima sarmentosa* L. contain a large quantity of water which travellers and local inhabitants often drink. Some slender stems of lianas are known to be used as 'bush-ropes'.

Dillenia and *Wormia* in South-East Asia and *Curatella* in tropical America yield timbers, which are not of much commercial importance. They find their way to local markets where they are used for general construction.

Of the 4 genera and 16 species indigenous to India, only *Dillenia* attains tree size and is considered here. The only other woody genus is *Delima*, which is represented by a single species namely *D. sarmentosa* L. [*Tetracera asiatica* (Lour) Hoogl.], – a large woody climber in Assam.

DILLENIA L.

A genus of trees and shrubs distributed widely in the tropical regions of the world, the largest number of species being confined to India and South-East Asia. About 11 species of trees are known to grow in the Indian region. Of the 6 species dealt with here, two namely, *D. indica* and *D. pentagyna* are of commercial importance.

The woods are similar in appearance and structure, and can not be separated with certainty; however, *D. indica*, *D. pentagyna* and *D. scabrella* appear to be somewhat coarser than *D. aurea* and *D. pulcherrima*.

1. **D. aurea** Smith—**dillenia.** *kalli* (Baiga), *byoo, byu, linshaw* (Burm.), *kalla, kalle, kallei, karmata, kerimgila* (Gon.), *aggai, aghai, chamaggai* (Hind.), *dheugr* (Nep.), *rai* (Or.), *korkotta* (Sant.), *china kalanga* (Tel.). A small to medium-sized tree up to 6–12 m. in height, usually with a crooked trunk and a clear bole of 1·5–3 m. and 90 cm.–2·7 m. in girth. *Bark* light brown or whitish-grey, smooth, peeling off in thin papery flakes, 1·3 cm. thick.

It is found in the sal forests along the base of the Himalayas from Pilibhit eastwards to Nepal and Bhutan, dry hilly regions of Bihar, Orissa and Madhya

Pradesh ascending up to 900 m. and in the drier hill forests of Burma at 600-900 m. – also in South-East Asia.

Description of the wood—See page 3.

2. **D. indica** L.—**dillenia.** *chumpa* (Abor), *ou-tenga, panchkol* (Asm.), *chalata, chalita, chalta, hargesa, hargese, hargeza, tartari* (Beng.), *masang, thabyu, tha-pyoo* (Burm.), *thaidi, thegdi-bapahng* (Cach.), *bau-changne* (Duff.), *otengah, otingah, panpui* (Garo), *chalta* (Hind.), *betta-kanagala, kad-kanagala, muchiru* (Kan.), *aitrang* (Kuki), *kyangmo-zhu, phamsikol, sungom* (Lep.), *aithlong* (Lush.), *syalita* (Mal.), *hiegri* (Manip.), *mota karmal, mota kermal* (Mar.), *thagit* (Mechi), *pumplang* (Mik.), *sampa, sompa* (Miri), *akshi, chauralesi, dabru, kalai, kaorkotta thapru* (Maghi), *dong-phang-thai* (Naga), *mechiaphal, panchphal, punchkule, ramphal* (Nep.), *oao, rai* (Or.), *korkot, korkotta* (Sant.), *uva* (Tam.), *pedda-kalinga, uva* (Tel.), *aitang, jong-phang* (Tipp.). A medium-sized to large tree up to 24 m. in height with a clear bole of 4·5–6 m. and 1·8 m. in girth. *Bark* reddish-brown, smooth to rough, peeling off in thin papery flakes, thin to moderately thick.

It is found in moist, evergreen forests of sub-Himalayan tract from Nepal eastwards extending to Burma, moister parts ot Madhya Pradesh, Andhra and Madras, chiefly along streams, – also throughout South-East Asia.

Description of the wood—See page 3.

3. **D. parviflora** Griff.—**dillenia.** *lingyaw, lingyow, linyaw* (Burm.). A middle to large-sized tree up to 18–21 m. in height, with a clear bole of 9–10·5 m. and 1·8–2·4 m. in girth. *Bark* greyish-brown, rough.

It is found in mixed forests of lower Burma, chiefly in Pegu, Martaban and Tenasserim up to 600 m. elevation and also in the dry forests of western Thailand.

Description of the wood—See page 3.

4. **D. pentagyna** Roxb.—**dillenia.** *akshi, okshi, otenga, oua* (Asm.), *mirshi* (Baiga), *akshi, argeza, hargeza, karkotta* (Beng.), *zinbyun* (Burm.), *boncholta* (Cach.), *kadutega, malegeru* (Coorg), *achki, akachi* (Garo), *kalla, kallai, kalli, sua* (Gon.), *aggai* (Hind.), *kad-kanagala, kaltega, kanagola, kangal, machil* (Kan.), *shukni, shukri-kung* (Lep.), *koddapanna, koddapunna, panna, pattipanna, vazhapunna* (Mal.), *kangalu kankera, karambel, kari, karmal karumbel, karweil, kurweil* (Mar.), *karanbidi* (Melaghat), *chirimpi* (Mik.), *chambruin, sahar, zambrun* (Maghi), *agor, tantri, tatera, tatri* (Nep.), *rai* (Or.), *akshi, chalta, kalai, korkot, otenga, rai, sahar* (Sant.), *naitek, nai-tekku, nay-teku, pinnai* (Tam.), *chinna-kalinga, pedda-kalanga, purudu, rawadan, revadi* (Tel.). A moderate-sized tree 15–21 m. in height with a clear bole of 7·5–10·5 m. and 1·8–2·4 m. in girth. *Bark* greyish-brown, peeling off in round thick flakes, about 1·3 cm. thick.

It occurs in the sal forests of the sub-Himalayan tract, from Oudh eastwards extending to Burma; in the deciduous forests of Madhya Pradesh, Peninsular India and Andaman islands ascending up to 600 m. – also throughout South-East Asia.

Description of the wood—See below.

5. **D. pulcherrima** Kurz (D. aurea Smith)—**dillenia.** *byoo, byu, linshaw* (Burm.). A medium-sized tree found chiefly in the eng forests of Burma.

Description of the wood—See below.

6. **D. scabrella** (D. Don) Roxb.—**dillenia.** *banji-ou* (Asm.), *hargeza* (Beng.), *mandiphang* or *mundle-phang* (Cach.), *agatchi-badura, akachi* (Garo), *mangie-thing* (Kuki), *chirimso* (Mik.). A tree 12–15 m. in height with a fluted trunk and a clear bole of 3–7·5 m. and 90 cm.–1·5 m. in girth. *Bark* greyish brown outside, light pink inside.

It is found in the forests of Assam, Sylhet, Chittagong and Andaman islands up to 900 m. elevation.

Description of the wood—See below.

Description of the wood

(*Dillenia aurea, D. indica, D. parviflora, D. pentagyna, D. pulcherrima* and *D. scabrella*).

[Pl. I, 1–6].

General properties—Sapwood yellowish-brown gradually merging into light brown heartwood; moderately hard to hard; moderately heavy to heavy (sp. gr. 0·58–0·82 air-dry); usually twisted or interlocked-grained; coarse and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by darker bands of fibrous tissue, 1–5 per cm. *Pores* moderately large to large, moderately few to moderately numerous (5–18 per mm.^{2}), but usually larger and fewer in *D. indica, D. pentagyna* and *D. scabrella* and occasionally so in *D. parviflora*; evenly distributed, mostly solitary but occasionally a few in tangential or oblique pairs, oval to angular, mostly open but sometimes filled with white deposits (vitreous silica) and tyloses; vessel lines prominent, scalariform perforations occasionally visible under hand lens on the radial surface. *Soft tissues* usually indistinct, when visible, appear as diffuse white dots under a lens. *Rays* of two size classes – broad to moderately broad, distinctly visible to the eye and fine to very fine, visible only under hand lens, the former widely and evenly spaced, the latter closely spaced between the broad rays; some of the rays show up as fairly large flecks on the radial surface.

Strength—Only *D. indica* and *D. pentagyna* have been tested; for strength figures see appendix I.

Seasoning—The wood of *D. indica* and *D. pentagyna* is moderately refractory to air seasoning. It has a slight tendency to split at the ends and to warp. Kiln seasoning offers no difficulties. The timber comes out in excellent condition provided it is well sawn and carefully piled. It also seasons well when cut from girdled logs.

Natural durability—Not durable; *D. indica* is reported to last 20–29 months and *D. pentagyna* 12–20 months.

Insect and fungus attack—Newly felled logs of *D. pentagyna* are laible to be attacked by shot-hole and pin-hole borers, e.g., *Xyleborus andrewesi* Bldfd., *X. butamali* Beeson, *X. noxius* Samps., *X. semigranosus* Bldfd. and *X. testaceus* Walk. (Family Scolytidae, order Coleoptera). *D. indica* is susceptible to the wood-rotting fungus *Fomes fastuosus* Lev., which causes heart rot.

Preservative treatment—Heartwood of *D. pentagyna* is refractory to treatment, and incision is necessary for 1 to 2 cm. penetration.

Working qualities—Information available is rather contradictory. This is probably due to the varying quantities of silica present in different consignments. It is usually easier to saw when green, but after seasoning it offers difficulties. It does not take fine polish and is unsuitable for high class cabinet making. The timber can be peeled after boiling.

Supply and uses—Large supplies are available in the east zone; the timber is also available in moderate quantities from the west zone. The largest supplies are available from the Buxa division in Bengal. The timber can be used after treatment for all constructional purposes where good strength is required. It is suitable for second class plywood and is also used for the manufacture of heavy packing cases, dugouts, country boats, oars, well-curbs and beading. It has been found suitable for use as railway sleepers after treatment. The wood has a high calorific value and yields an excellent firewood and charcoal.

Material—

D. aurea – 4829 Gorakhpur, U.P. (0·74).

D. indica – 396 Darjeeling terai (0·62), 1395 Chittagong (0·75), 2310 Darjeeling terai (0·60), 5176 Kamrup, Assam (0·66), 6243 Tavoy, Burma (0·61), 7275 Sadiya, Assam (0·58), 7335 Darrang, Assam (0·62), 7357 Kamrup, Assam (0·55), 7508 Sibsagar, Assam (0·66), 7572 Kamrup, Assam (0·60).

D. parviflora – 4876 Pegu, Burma (0·81), 5034 Burma (0·64), 6175 Thaton, Burma (0·71), 6304 Burma (0·78).

D. pentagyna – 302 Burma (0·69), 348 Gorakhpur, U.P. (0·82), 557 Prome, Burma (0·77), 658 Darjeeling terai (0·62), 2311 Darjeeling terai (0·72), 5794 Kanara (0·74), 5851 South Kanara (0·66), 5927 South Kanara (0·73), 5958 Palghat (0·66).

D. pulcherrima – 5017 Pegu, Burma (0·67), 5050 Thongwa, Burma (0·71), 5063 Burma (0·67), 6395 Burma (0·82).

D. scabrella – 4864 Goalpara, Assam (0·60), 5687 Chittagong (0·77).

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K. A. CHOWDHURY AND D. N. BADOLA

2. MAGNOLIACEAE

The family comprises of 10 genera and approximately 150 species of trees and shrubs, widely distributed in the tropical and temperate regions of America and Asia, and a few extending to Australia and New Zealand. Geological records show that members of this family were extensively distributed in northern hemisphere up to Greenland, and in the southern hemisphere up to Australia during the Cretaceous and Tertiary Periods.

Many members of this family are cultivated for their showy and sweet-scented flowers and beautiful leaves; well known among them are *Liriodendron tulipifera* L., *Magnolia grandiflora* L., and *Magnolia macrophyla* Michx. Essential oils from the flowers are used for the manufacture of perfume. Decoction of bark of some members of the family is also reported to be of medicinal value.

The family includes some well known timbers like 'yellow-poplar wood' and 'cucumber magnolia' of North America, produced by *Liriodendron tulipifera* L., and *Magnolia acuminata* L. Various species of *Magnolia*, *Manglietia*, *Michelia* and *Talauma* also produce timbers of commercial importance.

In addition to the four Indian genera mentioned above, there is one more, namely *Pachylarnax* Dandy.* This includes a single species of large sized tree of Assam, for which we had no sample for examination.

The woods of the family are remarkably homogeneous both in anatomical characters and physical properties. The colour varies from yellowish-white or olive-green to light brown. They are soft to moderately hard, light to moderately heavy and medium-fine in texture. The woods are diffuse-porous and are characterised by concentric bands of soft tissues (terminal parenchyma) demarcating the growth rings with the solitary exception of *Magnolia pealina*.

1. MAGNOLIA L.

Trees and shrubs of this genus are distributed throughout tropical and temperate East Asia and North America; probably more frequent in the tropics. About 6 species are known to grow in India of which 4 were available for this study.

1. M. campbellii Hk. f. & Th.—**magnolia.** *champ* (Beng.), *patagari*, *pendder* (Bhut.), *sagok*, *sigumgrip* (Lep.), *lal champ*, or *ghoge champ* (Nep.). A tall tree, 18–24 m. high with clear bole 9–15 m. long and 3–3·7 m. in girth. *Bark* dark coloured and almost black on branches.

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* The genera *Euptelea*, *Illicium*, *Kadsura* and *Schizandra* are no longer in this family; *Euptelea* Sieb. & Zucc. is now in *Trochodendraceae*, *Illicium* L. in *Winteraceae* and *Kadsura* Kaemfer & *Schizandra* Michx. in *Schizandraceae*.

It is found in the Himalayas from Nepal eastwards at 2,100–3,000 m. elevation.

Description of the wood—See below.

2. **M. globosa** Hk. f. & Th.—**magnolia.** *khukie champ, kokre champ* (Nep.). A small tree, 6–7·5 m. in height with clear bole of 3–4·5 m. and 60–90 cm. in girth. *Bark* light greyish-brown, smooth with shallow vertical clefts and regular horizontal wrinkles, arranged close together.

It occurs in Sikkim at 2,700–3,000 m. elevation.

Description of the wood—See below.

3. **M. pealiana** King—**magnolia,** *gahori sopa* (Asm.). A middle sized tree. *Bark* dark grey with longitudinal wrinkles.

It is found in Lakhimpur, Assam.

Description of the wood—See below.

4. **M. pterocarpa** Roxb.—**magnolia.** *barmpthuri-sopa, thouthua* (Asm.), *doloi-champa, lairouthou-bumphang* (Cach.), *dieng-long-krop, dieng soh bar-synrang, dieng-soh dkhar* (Kh.), *chapite jamja, phapitem-haija* (Kuki), *utham-bau* (Manip.), *patpate* or *chanp* (Nep.), *duli champa* (Sylh.), *chapite jamja* (Tipp.). A medium to large-sized tree, about 21 m. high. *Bark* grey, rough, warty.

It is distributed in the sub-Himalayan tracts from Nepal eastwards to Assam, in Chittagong hill tracts and in the hill forests of Burma.

Description of the wood—See below.

Description of the wood

(*Magnolia campbellii, M. globosa, M. pealiana* and *M. pterocarpa*)

[Pl. 2, 7]

General properties—Wood white, turning light yellowish-brown on ageing; soft to moderately hard; light to moderately heavy (sp. gr. 0·41–0·64 air-dry); usually straight-grained and fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by concentric bands of soft tissues (terminal parenchyma) except in *M. pealiana* in which somewhat dark fibrous bands form the growth marks – not the terminal parenchyma, 3–12 per cm. *Pores* small to moderately large, moderately numerous to numerous (10–38 per mm.^{2}), evenly distributed, solitary or in radial multiples of 2–3, round to oval, usually plugged with tyloses and occasionally with whitish deposits; vessel lines inconspicuous, scalariform perforation usually visible on the radial surface except in *M. campbellii*. *Soft tissues* in concentric bands, delimiting the growth rings

and also occasionally forming false growth marks but indistinct under hand lens in *M. pealina*. *Rays* fine to moderately broad, fairly closely spaced, evenly distributed.

The timber has not been tested for strength but is reported to be quite strong. It is not durable when exposed to outside conditions.

Insect attack—The entire interior of the sapwood of *M. campbellii* is reduced to powder and the external surface is left nearly intact as a thin papery sheet by the dry wood borer *Stromatium barbatum* Fabr. (Family Cerambycidae, order Coleoptera). In *M. pterocarpa* the sapwood is liable to be attacked by *Glenea lecta* (Family Cerambycidae order Coleoptera,) but the damage is only superficial which can generally be removed during conversion.

Working qualities—It works well with tools as any other species of this family.

Supply and uses—The timber is not available in commercial quantities. It is locally used for building purposes and for planking. It is an excellent wood for plywood and suitable for all indoor works and turnery articles.

Material—

M. campbellii – 365 Darjeeling (0·41).
M. globosa – 5088 Darjeeling (0·57).
M. pealiana – 5604 Lakhimpur, Assam (0·64).
M. pterocarpa – 6415 Burma (0·61).

2. MANGLIETIA Blume

A genus of trees and shrubs which is confined to tropical Asia. Three species have been reported from the Indian region. The species not available for study is *Manglietia caveana* Hk. f. & Th. – a tree of Assam. Gamble considers it to be a possible variety of *M. insignis* Blume.

1. **M. hookeri** Cubitt. & W. W. Smith—*pan sopa, phulsopa* (Asm.), *magrilakung* (Burm.). A large tree. *Bark* grey, smooth.

It is found in evergreen forests of Lakhimpur and Sibsagar in Assam and in the Kachin hills of Burma.

Description of the wood—See page 9.

2. **M. insignis** Blume—*pan sopa, phulsopa* (Asm.), *kaung, taung-saga, tondon* (Burm.), *dieng-rhi-balih* or *dieng-rhi-basau* (Kh.), *seete soah* (Nep.). A large tree, 24–27 m. high and 1·5–2·1 m. in girth. *Bark* greyish-white to reddish-brown with faint vertical fissures and fine horizontal wrinkles.

It is found in the foot hills of Assam below 750 m. and in the hill forest of upper Burma

Description of the wood—See below.

Description of the wood

(*Manglietia hookeri* and *M. insignis*)

[Pl. 2, 8]

General properties—Wood yellowish-white to olive-brown; soft to moderately hard; light to moderately heavy (sp. gr. 0·44–0·64 air-dry); straight to slightly twisted-grained; fine to medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by concentric bands of soft tissues (terminal parenchyma), 1–5 per cm. *Pores* small to moderately large, moderately few to numerous (8–28 per mm.^{2}), evenly distributed, solitary or in radial multiples of 2–4, oval or angular, often plugged with tyloses and sometimes with whitish deposits; vessel lines inconspicuous, scalariform perforation usually visible on the radial surface under hand lens. *Soft tissues* in concentric bands delimiting the growth rings. *Rays* fine, fairly closely spaced, evenly distributed.

Strength—The timber has not yet been tested for strength. The strength figures given by Maurand for the Indochinese species *M. glauca* and *M. fordiana* (density 0·42 to 0·56 at 15% moisture content), show that these are comparable to those of our michelias. Compression parallel to the grain (maximum crushing stress) being 300 to 400 kg. per cm.^{2} and the static bending (modulus of rupture) 700 to 900 kg. per cm^2.

Seasoning—One of the slowest drying timbers which do not give off moisture easily during seasoning, though not much liable to splitting and cracking.

Natural durability—*M. hookeri* is reported to be very durable (Kanjilal & Das) but Gamble states that *M. insignis* "does not last in the ground". The timber is quite durable under cover.

Working qualities—Works well with tools and saws well, planes to a smooth surface and takes up fine polish.

Uses—It is very good for indoor works, furniture, plywood and for turnery articles.

Material—

M. hookeri – 5560 Bhamo, upper Burma (0·54).

M. insignis – 5529 Darrang, Assam (0·64), 5559 Lakhimpur, Assam (0·53), 5611 Garo hills, Assam (0·46), 7369 Sibsagar, Assam (0·57), 7412 Lakhimpur, Assam (0·53), 7633 Sibsagar, Assam (0·44), 7968 Assam (0·47).

3. MICHELIA L.

Shrubs and trees; confined to the temperate and tropical East Asia (Indo-Malayan region) and Japan. In India it is represented by about 11 species, of which eight were available for study. The woods are indistinguishable.

1. **M. cathcartii** Hk. f. & Th. [**Alcimendra cathcartii** (Hk. f. & Th.) Dandy]—**champ.** *dieng rai* (Kh.), *atokdung, gokdum* (Lep.), *kala champ, titi champ* (Nep.). A large evergreen tree, 18–34 m. high with clear bole 6–9 m. long and 1·2–2·4 m. in girth.

It is distributed in Sikkim Himalayas at 1,500–2,100 m. and Khasia and Naga hills of Assam.

Description of the wood—See page 11.

2. **M. champaca** L.—**champ.** *tita sopa* (Asm.), *champa, champaca, champak* (Beng.), *saga, sagawa, saugo* (Burm.), *bol-nabat* (Garo), *champa* (Hind.), *champari phang* (Kach.), *shap* (Kh.), *kola sampige, sampige* (Kan.), *champakam* (Mal.), *kud champa* (Mar.), *serjoasing* (Miri), *ching-kappa* (Naga), *oulia champa, phul champa* (Nep.), *kanchanam* (Or.), *hapu, sapu* (Sinh.), *lal champa* (Synt.), *chambegam, sampangan, shimbu* (Tam.). A tall tree, 30 m. in height, 2·4–3·7 m. in girth with a clear bole of 18–21 m. *Bark* grey, smooth, about 1·3 cm. thick.

It is found from Nepal eastwards to the Abor country along the foot-hills up to 900 m. elevation. In the Lakhimpur division of Assam, in the Chittagong hill tracts, in southern Burma and on the west coast from Kanara southwards. Cultivated every where and run wild, it is, therefore, difficult to determine the exact limit of this species in a wild state (Pearson and Brown).

Description of the wood—See page 11.

3. **M. excelsa** Blume ex Wall. (**M. doltsopa** Buck.-Ham. ex DC.)—**champ.** *gok* (Bhut.), *dieng-rai* (Kh.), *penre, sigugrip* (Lep.), *bara champ, chanp, safed champ, seti champ, seto chanp* (Nep.). A lofty tree 18–30 m. high with a clear bole 12–15 m. long, 3–4·6 m. in girth. *Bark* dark grey with fine horizontal wrinkles.

It is found in the Himalayas from Nepal eastwards at 1,500–2,400 m. elevation and in the Khasi hills; one of the most important timber trees of upper Darjeeling forests.

Description of the wood—See page 11.

4. **M. kisopa** Ham. ex DC.—**champ.** *ban-champ* (Kumaon), *champ, chobsi* (Nep.). A tall tree. *Bark* grey, smooth.

It is found in the central Himalayas from Kumaon to Nepal at 1,500–2,100 m. elevation.

Description of the wood—See below.

5. **M. lanuginosa** Wall.—**champ.** *dieng-lali* (Kh.), *gogay-champ* or *phusre champ* (Nep.). A large tree up to 27 m. in height with a clear bole of 6–9 m. and 1·2–2·4 m. in girth. *Bark* greyish brown.

It is found in eastern Himalayas from Nepal eastwards at 1,500–1,800 m. elevation and also in the Khasi hills.

Description of the wood—See below.

6. **M. mannii** King—**champ.** *kothalua-sopa* (Asm.). A middle sized evergreen tree.

It is found in the Lakhimpur district of Assam.

Description of the wood—See below.

7. **M. nilagirica** Zenk.—**champ.** *pila champ* (Mar.), *wal sapu* (Sinh.), *shembugha* (Tam.). A moderate sized to large tree. *Bark* brown, peeling off in small rectangular pieces, 1·3 cm. thick.

It is found in the Nilgiris, Pulneys and other hills in the Peninsula and in Ceylon, above 1,500 m., often cultivated.

Description of the wood—See below.

8. **M. oblonga** Wall.—**champ.** *bor sopa, phul sopa, sopa* (Asm.). A lofty tree up to 46 m. in height and more than 4·3 m. in girth at the base. *Bark* grey, rough, warty.

It is a fairly common tree of the evergreen forests of Assam.

Description of the wood

(*Michelia champaca, M. cathcartii, M. excelsa, M. oblonga, M. lanuginosa, M. manii, M. nilagirica* and *M. oblonga*)

[Pl. **2,** 9–12 ; Pl. **3,** 13]

General properties—Sapwood white to greyish-white, heartwood yellowish-olive-green to olive-brown to pale brown ; soft to moderately hard ; light to moderately heavy (sp. gr. 0·39–0·60 air-dry), usually straight-grained ; fine to medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by concentric bands of soft tissue (terminal parenchyma), 1–5 per cm. *Pores* small to moderately large, evenly distributed but sometimes larger and more crowded in the early wood, few to very numerous (7–72 per mm.^{2}), solitary or in radial multiples of 2–3, round or oval, occasionally filled with tyloses and

with whitish deposits; vessel lines inconspicuous, scalariform perforation usually visible on the radial surface. *Soft tissues* in narrow concentric bands delimiting the growth rings and sometimes forming false growth marks. *Rays* fine, fairly closely spaced, evenly distributed.

Strength—*M. cathcartii*, *M. champaca*, *M. excelsa* and *M. oblonga* have been tested; for strength figures see appendix I.

Seasoning—The timber is moderately refractory but can be seasoned without difficulty or degrade, if properly handled. The logs should be converted green and then stacked in plank and scantling form in a sheltered, well ventilated shed. Kiln seasoning has also proved successful but there is slight discoloration of timber. It is liable to crack if proper care is not taken.

Natural durability—Only three species have been tested, viz., *M. cathcartii*, *M. champaca* and *M. excelsa*. None of the timbers lasted for more than 5 years in the open; *M. excelsa*, however, was found to be the least durable (9–28 months).

Insect attack—Constructional timber of *M. champaca* is liable to be bored by *Xylocopa* sp. (Family Xylocopidae, order Hymenoptera). Newly felled logs of *M. excelsa* and *M. nilagirica* are liable to be attacked by *Diapus* spp. and by the shot-hole borer *Platypus furcatus* Bldfd. (Family Platypodidae, order Coleoptera), respectively and the dry woods by *Stromatium barbatum* Fabr. (Family Cerambycidae, order Coleoptera).

Preservative treatment—Experiments carried out on *M. champaca* and *M. excelsa* have proved that the heartwood is very refractory to treatment, side and end penetration is practically nil.

Working qualities—The timber is easy to saw and works well with tools and finishes to a smooth glossy surface which stains and polishes well. It peels easily and economically.

Supply and uses—Large supplies are available from the eastern zone, mostly from Assam. Logs of large sizes particularly of *M. excelsa*, are usually available. It is an excellent timber for light furniture and the manufacture of plywood and is suitable for all indoor works. It is also locally used for constructional purposes and for planking. The finer textured samples are suitable for the manufacture of turnery articles.

Material—

M. cathcartii – 2314 Darjeeling (0·60).

M. champaca – 576 Darjeeling (0·53), 1049 eastern Duars, Bengal (0·54), 1437 Mishmi hills, Assam (0·56), 2195 Nowgong, Assam (0·56), 2313 Darjeeling terai (0·56), 2704 Dibrugarh, Assam (0·46), 5110 Tista valley, Darjeeling (0·50), 5665 Lakhimpur,

Assam (0·59), 5806 Buxa, Bengal (0·53), 7265 Kurseong, (0·50), 7282 Jalpaiguri, Bengal (0·52), 7319 Kalimpong, Bengal (0·61), 7323 Lumding, Assam (0·66), 7525 Tinnevelly, Madras (0·58), 7579 Chittagong (0·58), 7603 Sadiya, Assam (0·48), 7643 Nowgong, Assam (0·65), 7891 Saravda, Bihar (0·59), 7893 Saravda, Bihar (0·50).

M. excelsa – 657 Darjeeling (0·47), 1442 Mishmi Hills, Assam (0·47), 2312 Darjeeling (0·47), 5256 Darjeeling (0·52), 6000 Darjeeling (0·55).

M. kisopa – 5721 Almora (0·51).

M. lanuginosa – 3099 Darjeeling (0·39), 3331 Darjeeling (0·44).

M. mannii – 7257 Lakhimpur, Assam (0·60), 7488 Lakhimpur, Assam (0·60).

M. nilagirica – 3879 Nilgiris (0·55), 6078 Madras (0·66), 6399 Ootacamund, Madras (0·56).

M. oblonga – 4703 Dibrugarh, Assam (0·58), 7411 Sibsagar, Assam (0·50), 7413 Lakhimpur, Assam (0·49), 7514 Lakhimpur, Assam (0·44).

4. TALAUMA Juss.

The genus comprises of medium to large-sized trees and shrubs which are distributed mostly in the tropical and sub-tropical regions of the world, except Africa. In India 4 species are known to occur; all excepting *T. andamanica* King, a small tree of the Andamans, were available for study.

1. **T. hodgsoni** Hk. f. & Th.—*burbang asing* (Abor), *boromthuri, boronthuri, dat bhola* (Asm.), *pan kakro* (Garo), *leigerau* (Kach.), *safun, siffoo* (Lep.), *laigungron* (Mechi.), *boronthari-orong* (Mik.), *tetere asing* (Miri), *bhalu khat, harre, patpatta* (Nep.). A tree 9–12 m. high with clear bole of 4·5–6 m. and 90 cm.–1·8 m. in girth. *Bark* grey, thin, smooth.

It is found in the lower hill forests ascending up to 1,800 m. in Sikkim, in the evergreen forests of Assam and in the hill forests of upper Burma.

Description of the wood—See page 14.

2. **T. phellocarpa** King (**Michelia baillonii** Finet & Gagnep.)—*korika sopa* or *khorika sopa, tita sopa* (Asm.), *champa* (Cach.), *bolmring* (Garo), *dauthu-kimdu-phang* (Kach.) *langlu-chikong-arong* (Mik), *dieng-lari, dieng rewi* (Synt.). A large tree up to 30 m. in height and 2·4 m. in girth. *Bark* grey, exfoliating in rectangular flakes.

It is found in the forests of Assam ascending up to 1,200 m.

Description of the wood—See page 14.

3. **T. rabaniana** Hk. f. & Th.—*sappa*, *sopa* (Asm.), *lai-makhan-phang* (Kach.), *kobarai ching* (Naga). A large tree attaining 21 m. in height and 1·8 m. in girth. *Bark* dark grey, rough 1·3–1·8 cm. thick.

It occurs in Garo, Khasia and North Cachar hills of Assam up to 1,200 m. and in Mergui, Burma.

Description of the wood

(*Talauma hodgsonii*, *T. phellocarpa* and *T. rabaniana*)

[Pl. 3, 14]

General properties—Sapwood yellowish-grey, heartwood observed in one sample of *T. hodgsonii*, greyish-black, sharply demarcated from the sapwood ; soft to moderately hard ; light to moderately heavy (sp. gr. 0·37–0·73 air-dry) ; straight to slightly twisted-grained ; fine to medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by concentric bands of soft tissue (terminal parenchyma), 2–5 per cm. *Pores* small to moderately large, moderately numerous to numerous (10–38 per mm.^{2}), evenly distributed, in radial multiples of 2–4 or solitary, usually plugged with tyloses ; vessel lines inconspicuous, scalariform perforation usually visible on the radial surface. *Soft tissues* in concentric bands delimiting the growth rings and also occasionally forming false growth marks. *Rays* fine, fairly closely spaced, evenly distributed.

The timber has not yet been tested for strength.

Seasoning—Seasons well if converted green and then seasoned under cover. Kiln seasoning of planks has proved successful. Sometimes develops few surface cracks.

Natural durability—Does not last when exposed or wet.

Insect attack—Logs of *T. hodgsonii* are liable to be attacked by pin-hole and shot-hole borers of the family Platypodidae, order Coleoptera.

Working qualities—Not difficult to saw, but caution should be taken to plane it properly otherwise the cross grains may tear off.

Supply and uses—Fair supplies are available from Assam. The timber is suitable for all purposes for which other woods of this family are used.

Material—

T. hodgsonii – 3100 Darjeeling (0·37), 5130 (0·64), 5840 Buxa, Bengal (0·73), 6831 Burma (0·65), 7968 Assam (0·47).

T. phellocarpa – 7256 Lakhimpur, Assam (0·53), 7489 Lakhimpur, Assam (0·53), 7527 Sibsagar, Assam (0·56), 7967 Assam (0·68).

T. rabaniana – 4881 Sylhet (0·50), 7966 Assam (0·68).

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K. A. CHOWDHURY AND R. SHAHI

3. ANNONACEAE

The "custard apple" family consists of trees, shrubs and climbers, which are widely distributed in the tropics and to a less extent in the sub-tropics. It is particularly well represented in the Indo-Malayan region. The number of genera and species in this family varies according to different botanists. Bailey includes 40–50 genera and 600 species, while Lawrence gives about 80 genera and 850 species.

The custard apple *Annona reticulata* L. and several other species of *Annona* are extensively cultivated in the tropics for the delicious fruits that they produce. Several species are also well known for their sweet scented flowers. For instance, *Artabotrys odoratissimus* R. Br., which is a popular garden plant in India. Again, the flower of *Cananga odorata* Hk. f. & Th., is the source of famous "ilang-ilang" perfume.

The most important timber of this family is the well known lance wood of commerce produced by *Oxandra lanceolata* (Sw.) Baill. of West Indies. It is used in the manufacture of fishing rods, billiard cues, archery bows and articles of turnery. Other timbers produced by members of this family are of local importance only. In India, *Miliusa*, *Sageraea* and a few others produce tough and elastic timbers which are used for the manufacture of tool handles, bentwood furniture, fishing rods and sports goods.

The family is represented in India by more than 20 genera and about 200 species both native and introduced, of which woods of 10 genera were available for study.

The colour of the wood ranges from various shades of yellow to grey to pale brown. The weight, hardness, and texture of the wood are very variable; mostly they are moderately hard to hard, moderately heavy to heavy, straight-grained and medium-textured; but light and soft in *Goniothalamus sesquipedalis*, *Orophea*, *Polyalthia* (partly) and *Unona latifolia*; the last named differs from the others in having a coarse texture, while a few samples of *Polyalthia* have finer texture than the rest. Anatomically the wood is very uniform. With the solitary exception of *Assimina triloba* Dunal of eastern U.S.A. which is typically ring-porous, the rest are diffuse-porous. They are characterized by soft tissues in thin, closely spaced tangential lines, which form a network with the rays. The pores are usually just visible or indistinct to the eye and are usually moderately few to moderately numerous, except in *Unona latifolia*. Rays are very variable but for the most part moderately broad.

Except *Unona latifolia* which is light and coarse-textured, the rest are difficult to separate in spite of the great variation that they show in their physical properties.

1. CYATHOCALYX CHAMPION

The genus *Cyathocalyx* comprises of trees, which are found in India and South-East Asia. In the Indian region two species have been reported to grow, of which one is dealt with here.

C. martabanicus Hk. f. & Th.—*bolong* (Garo), *hrieroth* (Lush.). A middle-sized to very large tree up to 43 m. in height and 1·8 m. in girth. *Bark* grey to dark brown, rather smooth and thin.

It is found in the Garo, Lushai and North Cachar hills of Assam and in Tenasserim and Martaban.

Description of the wood

[Pl. 3, 16]

General properties—Wood yellowish, turning brownish with age; very hard; heavy (sp. gr. 0·87 air-dry); lustrous; straight-grained; medium-textured with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by darker bands of fibrous tissues, 5–6 per cm. *Pores* moderately large to small, just visible to the eye, few to moderately few (4–9 per mm.^{2}), evenly distributed, solitary or in radial multiples of 2, occasionally up to 4, roundish; vessel lines inconspicuous. *Soft tissues* distinctly visible under a hand lens, in fine evenly spaced tangential lines, forming a conspicuous network with the rays. *Rays* moderately broad, distinctly visible to the naked eye, rather widely spaced and evenly distributed : radial flecks prominent.

No information on the physical properties of this species is available except that the timber is elastic. Reyes mentions that the wood of *C. globosus* Merr. of the Philippines (sp. gr. 0·91–0·95 air-dry) is "very strong as may be judged from its density, seasons well with little or no warping; somewhat hard to work on account of hardness and the hard white deposits that dull tools readily; sapwood not durable, but heartwood resistant to insects as well as to decay".

Uses—It is likely to be suitable for tool handles, cart wheels, and the like where toughness is the most important quality of the timber.

Material—
6337 Burma (0·87).

2. GONIOTHALAMUS BLUME

The genus *Goniothalamus* comprises of small trees and shrubs, which are natives of South and South-East Asia. Of about 7 species indigenous to India, two were available for study.

1. **G. griffithii** Hk. f. & Th.—A large shrub or a small tree, found in the evergreen forests of Martaban and Tenasserim.

Description of the wood—See below.

2. **G. sesquipedalis** Hk. f. & Th. [**G. sesquipedalis** (Wall.) Hk. f. & Th.]—*skum-synsar, soh-um-synrang* (Kh.), *singnyok-kung* (Lep.), *kham* (Lush.), *leikham* (Manip.), *sane* (Nep.). A small shrub 1–2·4 m. high. *Bark* black.

It is found at the foot of the Sikkim Himalayas ascending up to 1,500 m., in the Khasi and Cachar hills of Assam up to 1,200 m. and in the Kachin hills and Tenasserim in Burma.

Description of the wood—See below.

Description of the wood

(*Goniothalamus griffithii* and *G. sesquipedalis*)

[Pl. 3, 17]

General properties—Wood yellowish-white to grey ; moderately hard and moderately heavy (sp. gr. 0·61 air-dry) in *G griffithii*, but soft and light (sp. gr. 0·40 air-dry) in *G. sesquipedalis* ; straight-grained ; medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* small to very small, moderately few to moderately numerous (5–11 per mm.^{2}) in *G. griffithii*, but extremely small, individually indistinct under hand lens, and few to moderately few in *G. sesquipedalis*, evenly distributed, solitary or in radial multiples of 2 but occasionally up to 4, roundish, mostly open, but in *G. griffithii* sometimes plugged with yellowish deposits ; vessel lines inconspicuous. *Soft tissues* clearly visible with a lens, in fine evenly spaced tangential lines, forming a conspicuous network with the rays. *Rays* broad to very broad, widely spaced, evenly distributed, forming a conspicuous fleck on the radial surface.

Uses—The timber is mostly used locally.

Material—

G. griffithii – 6830 Burma (0·61).
G. sesquipedalis – 3300 Darjeeling (0·40).

3. MILIUSA LESCH.

The genus *Miliusa* comprises of small trees and shrubs which are widely distributed in India, South-East Asia and Australia. About eight species occur in India, three of which are described here.

1. **M. roxburghiana** (Wall.) Hk. f. & Th.—*bon-ponial, chagg-loti, chag-ladoi, jora-bhanora* (Asm.), *thabut-thein* (Burm.), *tase-mayang-changne* (Duff.),

dieng-khong (Kh.), *sungden-kung* (Lep.), *dieng-jwat* (Synt.). A small to medium-sized tree 6 m. to 15 m. in height. *Bark* grey, fairly smooth.

It occurs in Sikkim Himalayas, most districts of Assam ascending to 1,200 m. in the Khasia hills, Chittagong hill tracts, and in Tenasserim.

Description of the wood—See below.

2. **M. tectona** Hutch. ex. C. E. Parkinson [**Saccopetalum tectonum** (Hutch. ex Parkinson) Chatterjee]—*jungli saguan* (Hind.). A straight-stemmed, moderate-sized to large tree 12–24 m. in height and 60 cm.–1·2m. in girth. *Bark* dark brown, thinly fissured.

It is found in the Andamans.

Description of the wood—See below.

3. **M. velutina** (Dunal) Hk. f. & Th.—*mai-nangsang, thabut-gyi* (Burm.), *gausal* (Garh.), *bor-samphol* (Garo), *Karli* (Gon.), *bari-kai, domsal, kajranta, kari* (Hind.), *daulo, ilar, kalpattin, kari, santha* (Kamaon), *siarbhuka* (Kharw.), *domgaru* (Khond), *ome* (Kol. and Sant.), *kanakaith* (Mal.), *gandha palas* (Or.), *domi-sal* (Punj.), *nalla dudduga, pedda chilka duduga* (Tel.), *kariota* (Th.). A moderate-sized tree 9–15 m. in height and up to 1·5 m. in girth. *Bark* brownish-grey, longitudinally fissured, rough, about 2·5 cm. thick.

It is a common tree of the deciduous forest of northern and central India especially with sal. It grows in the sub-Himalayan tract from Ganga eastwards, in Assam, Orissa, Andhra, Madhya Pradesh, Travancore and Burma.

Description of the wood—See below.

Description of the wood

(*Miliusa roxburghiana*, *M. tectona* and *M. velutina*)

[Pl. 3, 18 ; Pl. 4, 19]

General properties—Wood yellow when freshly cut but turns yellowish-grey or greyish-brown on exposure ; hard ; heavy (sp. gr. 0·75–0·79 air-dry) ; somewhat lustrous ; straight-grained ; and even and medium fine-textured with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker coloured fibrous tissue, 4–10 per cm. *Pores* small to very small, clearly visible with a lens, moderately few to numerous (9–28 per mm.^{2}), uniformly distributed, mostly in radial multiples of 2–4, occasionally up to 10, and a few in clusters of 3–5 and also solitary, usually arranged in a single row between the rays but occasionally also in two rows, mostly open but a few filled with yellowish gummy substance ; vessel lines inconspicuous. *Soft tissues* not visible to the naked eye, but distinct under hand lens, in fine

tangential lines, evenly spaced, forming a network with the rays; these lines are somewhat straight in *M. velutina* and *M. tectona* but a little wavy in *M. roxburghiana*. *Rays* moderately broad to fine in *M. velutina* and *M. tectona* and broad to moderately broad in *M. roxburghiana*, the broader rays rather widely spaced and evenly distributed and form a conspicuous fleck on the radial surface. *Pith flecks* observed only in *M. roxburghiana*.

The information given here is for *M. velutina*. The other two species have not yet been tested for strength, seasoning etc.

Strength—See appendix I.

Seasoning—It is a difficult timber to season as it develops end-splits, though not liable to surface cracking. According to Gamble it is rather liable to warp. Pearson and Brown recommend that "the timber should be converted green and open stacked under cover to prevent excessive splitting as well as to avoid stain to which it is somewhat liable".

Natural durability—Not durable; reported to last for 9 to 22 months.

Working qualities—"The timber is easy to saw, machines well, lends itself to turnery; finishes with a good surface" Pearson and Brown.

Supply and uses—Large supplies are not available in any one locality. However, sufficient quantities are available from Uttar Pradesh, for the manufacture of hammer and tool handles, for which the timber is mostly used. In South India, it is usually used for cheap building constructions, flooring, ceiling planks, furniture, packing cases and gunstocks. In Burma, it is reported to be used for shafts, oars, spear shafts, yokes, axles, poles of carts and agricultural implements.

Material—

M. roxburghiana – 2316 Darjeeling (0·77).

M. tectona – 7826 Andamans (0·79).

M. velutina – 3062 Prome, Burma (0·76), 3113 Dehra Dun (0·75), 3122 Burma (0·69), 4799 Saharanpur (0·75), 6049 Porahat, Singhbhum (0·79), 6074 Cuddapah (0·78).

4. MITREPHORA Blume

A genus of trees and shrubs which are found in South and South-East Asia. Two out of about 7 species found in India are described here.

1. **M. maingayi** Hk. f. & Th. (**M. maingayi** var. *Kurzii* King)—*thabut-net* (Burm.). A tree, 6–15 m. in height, found in Burma.

Description of the wood—See page 21.

2. **M. vulpina** C. E. C. Fischer—A tree, 24–27 m. high, found in Tenasserim, Burma.

Description of the wood—See below.

Description of the wood
(*Mitrephora maingayi* and *M. vulpina*)

[Pl. 4, 20]

General properties—Wood light yellow-brown, moderately hard to hard; moderately heavy to heavy (sp. gr. 0·67–0·81 air-dry); straight-grained; medium and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* visible to the naked eye as faint lines formed by darker coloured fibrous tissue, 3–7 per cm. *Pores* small to moderately large, barely visible to the naked eye, moderately few to moderately numerous or numerous (7–21 per mm.^{2}), uniformly distributed, solitary or in radial multiples of 2–4, occasionally up to 6, usually in a single row between two rays but sometimes in two rows, round to oval, mostly open but a few filled with yellowish-white deposits; vessel lines inconspicuous. *Soft tissues* indistinct to the eye, but distinct under hand lens, in fine closely spaced tangential lines forming a network with the rays depicting a ladder-like arrangement. *Rays* moderately broad to fine, rather widely spaced and evenly distributed, radial flecks present but not prominent.

Uses—It is reported to be used for spokes of cart wheels, and walking sticks. Like other members of this family, the wood is suitable for tool and hammer handles.

Material—

M. maingayi – 5507 upper Chindwin, Burma (0·67); 5519 Thangyin, Burma (0·77), 5568 Shwebo, upper Burma (0·74), 6561 Burma (0·81).

M. vulpina – 6594 Burma (0·78).

5. OROPHEA Blume

The genus *Orophea* comprises of small trees and shrubs, which are widely distributed in India and South-East Asia. About five species are indigenous in India, of which only one was available for study.

O. hexandra Blume—A small tree 4·5–6 m. in height and 30–60 cm. in girth found in the middle and South Andamans and in Burma, especially in Tenasserim.

Description of the wood

[Pl. 4, 21]

General properties—Wood yellowish-white; moderately hard; light; straight-grained; medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker coloured fibrous tissues, about 8 per cm. *Pores* small to very small, distinctly visible under hand lens, moderately few (5–10 per mm.^{2}), evenly distributed, solitary or in radial multiples of 2 to 3, round; vessel lines inconspicuous. *Soft tissues* indistinct to the eye but distinctly visible under hand lens, characteristically arranged in closely and evenly spaced fine tangential lines, forming a network with the rays. *Rays* moderately broad to fine, broader ones distinctly visible to the naked eye, widely spaced and evenly distributed, forming a conspicuous fleck on the radial surface.

Uses—The timber is mostly used locally.

Material—

6246 Tavoy, Burma.

6. POLYALTHIA BLUME

A genus of trees and shrubs, which are widely distributed from tropical Africa and Madagascar through tropical Asia to Australia but most numerous in South-East Asia. In the Indian region the genus is represented by about ten species, of which seven are described here.

1. **P. andamanica** Kurz—**debdaru.** A shrub found in the South and middle Andamans. This species is now considered by some botanists as not distinct from *P. jenkinsii* (Hk. f. & Th.) Hk. f. & Th. a tree of Assam.

Description of the wood—See page 23.

2. **P. cerasoides** (Roxb.) Bedd.—**debdaru.** *Gyoban, thabut-thein* (Burm.), *kadumi, kala karai, lahan karai* (Hind.), *habbe, sanhesare, vabbina* (Kan.), *sande ome* (Kol.), *narelai* (Mal.), *hoom* (Mar.), *potmossu* (Or.), *panjon, rida* (Sant.), *kathukala, kathukovai, kodugilai, mullili, nedunarai, nettilingi* (Tam.), *chlakadudduga, guttii* (Tel.). A shrub (in Assam) to moderate-sized tree (in Kanara) which usually branches low down. *Bark* grey, rough, thin.

It is found on the dry hills from Chotanagpur southwards to Travancore, throughout the monsoon forests of the Western Ghats but nowhere common; also in Assam and lower Burma.

Description of the wood—See page 23.

3. **P. fragrans** (Dalz.) Bedd.—**debdaru.** *gauri, murgauri* (Kan.), *chella, nedunar, pullarrei* (Mal. and Tam.). A tall straight handsome tree, found in the forests of Western Ghats from the Ratnagiri District southwards to Travancore up to 1,200 m. elevation.

Description of the wood—See page 23.

4. **P. lateriflora** (Blume) King—**debdaru.** A tree 6–20 m. high. *Bark* greyish-brown finely cracked with horizontal ridges (Sinclair).

It is found in Thaton and Mergui in Burma – also in Thailand, Malaya, Java and Sumatra.

Description of the wood—See below.

5. **P. longifolia** Benth. & Hk. f. [**P. longifolia** (Sonnerat) Thw.]—**debdaru.** *unboi* (Asm.), *debdaru* (Beng.), *asok, debdar, deodar* (Bihar and Or.), *asok, asuphal* (Bombay), *ashok, devidari* (Hind.), *pungu, puttrajivi* (Kan.), *arana kolerengi, nedunar* (Mal.), *asoka, nottulingam* (Tam.), *asoka, devadaru* (Tel.). A tall handsome tree with straight trunk and crown like a pyramid. *Bark* dark grey to dull brownish, smooth, thick.

Though said to be indigenous in South India and Ceylon, it is cultivated all over India as an avenue tree and near temples. It is found as far north as Hoshiarpur in the Punjab.

Description of the wood—See below.

6. **P. simiarum** Benth. & Hk. [**P. simiarum** (Hk. f. & Th.) Hk. f. & Th.]—**debdaru.** *boga-khamtou, bor-koliori* (Asm.), *champa* (Bhum.), *taw-sagasein, taw-thabut* (Burm.), *bolanf-banchibok, borsthi* (Garo), *senem-phang, silem-phang* (Kach.), *deing-ja-roi, deing-lar-sei* (Kh.), *jethou* (Kuki), *khandou* (Mechi), *mengchuri-arong, phangput-arong* (Mik.), *mikir-asing* (Miri), *khari* (Modesia), *khutti, labshi* (Nep.), *ojhar, wojarh* (Or.), *dighi bentia* (Sant.), *jathou* (Tipp.). A tall, rather slender, tree up to 30 m. in height and 2·4 m. in girth.

It is found in the moist forests of Orissa, Mayurbhanj, in lower hill forests of North Bengal, Assam, Chittagong hill tracts, and Burma.

Description of the wood—See below.

7. **P. suberosa** Benth. & Hk. f. [**P. suberosa** (Roxb.) Thw.]—**debdaru.** *bara chali* (Beng.), *cham-khirai, kharia, khirni* (Hind.), *makhamsra-phang* (Kach.), *habida-cha* (Mik.), *burhi chamri, karadia, lohania mossu* (Or.), *dudduga* (Tel.). A large shrub or a small tree. *Bark* brown, very thickly corky.

It is found in the forests of Singhbum, Orissa, and Eastern Ghats, Nilgiris and Mysore, also in Assam and Burma (Tenasserim).

Description of the wood—See below.

Description of the wood

(*Polyalthia andamanica, P. cerasoides, P. fragrans, P. lateriflora, P. longifolia, P. simiarum* and *P. suberosa*)

[Pl. 4, 22–24 ; Pl. 5, 25]

General properties—Sapwood greyish to brownish-yellow, heartwood grey black, sharply differentiated from the sapwood (only in one sample of *P.*

cerasoides) ; moderately hard ; moderately heavy (sp. gr. 0·51–0·86 air-dry) ; usually straight-grained ; medium to fine to very fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker coloured fibrous tissues, 3–6 per cm. *Pores* usually small to very small, clearly visible under hand lens, moderately few to moderately numerous (6–18 per mm.^{2}), but in one sample of *P. fragrans* and in two samples of *P. suberosa*, extremely small, not individually distinct under hand lens and numerous to very numerous, uniformly distributed, solitary or in radial multiples of 2–3, occasionally up to 6, roundish, sometimes filled with yellowish deposits. *Soft tissues* distinct only under hand lens, in fine evenly spaced tangential lines forming a net-like structure with the rays. *Rays* usually moderately broad to fine and rather widely spaced but fine to very fine in *P. suberosa* and in a sample of *P. fragrans*, and broad to moderately broad in *P. simiarum* ; radial flecks present, conspicuous in the samples having broader rays.

Strength—Only *P. fragrans* and *P. simiarum* have been tested ; for strength figures see appendix I.

Seasoning—Logs of *P. simiarum* and *P. cerasoides* are liable to develop serious splits. Sawn planks are also prone to splitting and surface cracking unless carefully stacked. The timber is liable to sapstain.

Natural durability—Not durable ; graveyard tests showed that *P. fragrans* lasts for 15–21 months.

Insect attack—Newly felled logs are liable to be attacked by shot-hole borers which makes the timber unsuitable for the manufacture of plywood. In *P. fragrans* shot-hole borers of the families Platypodidae and Scolytidae have been recorded. The borer *Crosso-tarsus saundersi* Chap., and also *Hucus loratus* Jordan, (Fam. Anthribidae) and *Parimamistena polyalthiae* Fischer, (Fam. Cerambycidae), have been found to attack *P. simiarum*.

Working qualities—The timber is not difficult to saw or work, and depending upon the texture finishes to rough or smooth surface.

Supply and uses—Limited supplies are available from the east, west and south zones. It is used for the manufacture of plywood, matches, packing cases and for temporary constructions. Some of the species are likely to be suitable for the manufacture of turnery articles.

Material—

P. andamanica – 6416 Burma (0·65).

P. cerasoides – 5434 Burma (0·81), 5487 Puri (0·86), 5508 Upper Chindwin, Burma (0·50), 5515 Tenasserim, Burma (0·66), 5516 North Kanara (0·76), 5579 Nasik, Bombay (0·75), 5569 Shwebo, Burma (0·74), 5636 N. Coimbatore (0·86), 997 Poona (0·79), 6057 Balugau, Orissa (0·80), 6459 Kodawady, Madras (0·84).

P. fragrans – 4593 Travancore (0·61), 6201 Kodawady, Madras (0·84).

P. lateriflora – 6806 Burma (0·63).

P. longifolia – 2479 Calcutta Bot. Garden (0·51).

P. simiarum – 6058 Balugau, Orissa (0·68), 6367 Burma (0·60), 7523 Darrang, Assam (0·63).

P. suberosa – 5486 Puri (0·76).

7. SACCOPETALUM Bennett.

A genus of moderate-sized to large trees, which is now combined by the systematic botanists with *Miliusa*. It is found in tropical Asia and Australia. Four species are known to grow in Indian region of which only two are dealt with here.

1. **S. tomentosum** Hk. f. & Th. [**Miliusa tomentosa** (Roxb.) J. Sinclair]— **hoom.** *hoom* (Bombay), *kutki, minmara, thoska* (Gon.), *kari, kirua* (Hind.), *hessare, wumb* (Kan.), *kari* (Kharw.), *ione* (Kheria), *ombe, ome* (Kol.), *kanakaitha* (Mal.), *gandhapalsa, patmosso* (Or.), *charra* (Sant.), *budda-dudduga, chilka dudi, gadithalotta* (Tel.). A moderate-sized to large deciduous tree. *Bark* dark greyish-brown to brown, rather rough and fissured.

It is found throughout the Uttar Pradesh from Pilibhit to Gorakhpur, Nepal terai, Bihar, Chotanagpur, Orissa, Andhra, Central India, Hyderabad, Western Ghats, from South Kanara to Tinnevelly, Gujerat and Rajputana.

Description of the wood—See below.

2. **S. unguiculatum** C. E. C. Fischer [**Miliusa tomentosa** (C. E. C. Fischer) J. Sinclair]. A tree 18–24 m. high, found in Tenasserim.

Description of the wood—See below.

Description of the wood

(*Saccopetalum tomentosum* and *S. unguiculatum*)

(Pl. 5, 26)

General properties—Wood yellow to olive-brown ; hard ; moderately heavy to heavy (sp. gr. 0·60–0·84 air-dry) ; straight-grained ; medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by bands of denser fibrous tissues, 2–5 per cm. *Pores* small to very small, distinctly visible under a hand lens (6–23 per mm.^{2}), uniformly distributed, solitary or in radial multiples of 2–3, occasionally up to 6, round, mostly open, sometimes filled with yellowish gummy substance. *Soft tissues* visible only under hand lens, in fine closely spaced tangential lines arranged

to form a reticulum with the rays. *Rays* broad to moderately broad, visible to the naked eye, rather widely spaced, evenly distributed, forming a conspicuous fleck on the radial surface.

The working qualities and physical properties given here are based on only *S. tomentosum*.

Strength—See appendix I.

Seasoning—A moderately refractory timber, being liable to some damage by surface cracking, splitting and warping. Green conversion promptly after felling, and stacking the sawn material in a well ventilated shed is recommended.

Natural durability—Not durable ; lasts for 23–65 months.

Working qualities—The timber is easy to saw and plane. It turns very easily on the lathe and gives a fine and smooth finish. It can be stained, polished and varnished well.

Supply and uses—Fair supplies are available from Bombay. In the Panch Mahals and North Thana divisions the exploitable trees vary in diameter from 90 cm.–1·2 m. and yield logs and poles from 4·5–6 m. in length. In the West Khandesh division there are few scattered trees 1·9–2·2 m. in diameter. Fair quantities in small sizes are also available from Uttar Pradesh. It is a suitable timber for the manufature of bobbins and it can be used as a substitute for imported birch and beech for other purposes also. It has also proved to be suitable for making bentwood furniture, sports goods, turnery articles and toys.

Material—

S. tomentosum – 1109 Ahiri Forest, M.P. (0·77), 3471 Chotanagpur (0·60), 5481 Santhal Parganas (0·84), 5488 Puri (0·78), 6197 Kanara (0·77), 6400 Ootacamund (0·72).

S. unguiculatum – 6596 Burma (0·73).

8. SAGERAEA Dalz

The genus *Sageraea* contains trees and shrubs which are found in India, Ceylon, Burma, Malayan Archipelago and the Philippines. The Indian region has four species, of these three are dealt with here.

1. **S. elliptica** (A. DC.) Hk. f. & Th.—Andaman bow-wood. *Chooi* (Andaman). A large tree with cylindrical or slightly fluted stem.

It is found in deciduous and semi-deciduous forests of the Andamans and in evergreen forests of Tenasserim – also in Malaya, Thailand and Borneo.

Description of the wood—See page 27.

2. **S. laurina** Dalz. [**S. laurifolia** (Grah.) Blatter]—*kanakayitha* (Mal.), *kar-kinjal*, *sajeri*, *undie* (Mar.), *nedu natta* (Tel.). A moderate-sized tree with a cylinderical stem up to 18 m. in height and over 90 cm. in girth. *Bark* dark grey and fairly smooth.

It is distributed in the evergreen forests of the Peninsula from Konkan to Travancore and also in Assam.

Description of the wood—See below.

3. **S. listeri** King – *dhaman* (Beng.). A moderate-sized tree found in Chittagong hill tracts and Burma (Bassein).

Description of the wood—See below.

Description of the wood

(*Sageraea elliptica*, *S. laurina* and *S. listeri*)

[Pl. 5, 27–29]

General properties—Wood yellowish-white turning light brown in colour on ageing; hard; moderately heavy to heavy (sp. gr. 0·74–0·81 air-dry); straight-grained; medium to fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by denser fibrous tissues, 3–6 per cm. *Pores* small to very small, distinctly visible with a hand lens, moderately few to numerous (5–29 per mm.^{2}), uniformly distributed, solitary or in radial multiples of 2–4 to 6, round, mostly open, sometimes filled with brownish-yellow gum. *Soft tissues* distinct only under lens, in closely and evenly spaced fine tangential lines, forming a sort of network with the rays. *Rays* moderately broad to fine, distinctly visible or just visible to the eye, moderately spaced, evenly distributed, radial flecks present, but not very conspicuous.

Information on strength and other properties available for only *S. elliptica* which is given here.

Strength—See appendix I.

Seasoning—Seasons fairly well if air-seasoned under cover. A few cracks appear but no discoloration takes place.

Working qualities—It is easy to work but during planing the wood is liable to tear up under the plane; it is suitable for steam bending.

Supply and uses—A very limited supply is available from the Andamans. The logs are cylindrical or slightly fluted, and are 4·5–7·5 m. in length and 30 cm. diameter. In the Andamans, the wood is used for boat-building and for bows. Being strong and elastic, it is an excellent timber for hammer and tool handles, axe helves and picking arms and similar purposes for which ash is used. It is also ideally suited for making fishing rods, bent-wood camp furniture, frames for motor car hoods, sports goods like golf clubs and billiard cues and also for carving and engraving.

Material—

S. elliptica – 7165 Burma (0·74). Two specimens 5220 (0·81) and 5221 (0·78) received as *Alphonsea ventricosa* (Roxb.) Hk. f. & Th.

(Pl. 3, 15), from the Andamans, are evidently of *S. elliptica*, as according to Parkinson, *A. ventricosa* does not grow in the Andamans.

S. laurina – 4587 Travancore (0·76).

S. listeri – 6314 Burma (0·81), 6866 S. Andamans (0·76).

9. UNONA L.

Trees and shrubs of this genus are distributed in India, Ceylon, South-East Asia. Of about 9 species indigenous to India, wood samples of two were available for study.

Key to the species

Wood soft, light and coarse-textured ... ... *U. latifolia*.

Wood moderately hard, moderately heavy and medium-fine-textured ... ... *U. longiflora*.

1. **U. latifolia Hk. f. & Th. [Cananga latifolia (Hk. f. & Th.) Finet & Gagnep].** A moderately-sized tree, 15 m. high and 60 cm. in girth.

It is found in the hill forests of Martaban, Burma and northern Malaya.

Description of wood

[Pl. 5, 30]

General properties—Wood yellowish-white ; soft ; light (sp. gr. 0·35 air-dry) ; straight-grained and coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by denser fibrous tissues, about 4 per cm. *Pores* large, outlines of the pores visible to the eye, few (3–5 per mm.^{2}) evenly distributed, solitary or in radial multiples of 2, occasionally 3–6, round ; vessel lines prominent. *Soft tissues* visible only under hand lens, in fine, evenly spaced, tangential lines forming a network with the rays. *Rays* moderately broad, distinctly visible to the eye, widely spaced, evenly distributed ; radial flecks conspicuous.

No information is available on the strength and other properties for this species ; Reyes mentions that the wood of *Cananga odorata* (Lamarck) Baillon (sp. gr. 0·32 air-dry) as "very weak ; seasons well ; easy to work ; very perishable ; readily damaged by termites and decay, and is used for making wooden shoes, fish-net floats etc.".

The wood of *Unona latifolia* is similar to that of *Bombax malabaricum* in texture, weight and hardness and is likely to be suitable for all purposes for which *Bombax* is used.

Material—

6667 Burma (0·35).

2. **U. longiflora** Roxb. [**Desmos longiflorus** (Roxb.) Saff.]—*jor-lewa* (Asm.), *meruang-omak* (Garo), *dieng-phallam* (Kh.), *theseming* (Mik.), *dieng-sa-la-tyrkai* (Synt.). A shrub or a small tree. *Bark* greenish-grey, smooth, thin.

It is found in the evergreen forests of Assam up to 1,100 m. elevation and in Chittagong and Orissa.

Description of the wood

[Pl. **6**, 31]

General properties—Wood yellowish-white, turning greyish with age ; moderately hard ; moderately heavy (sp. gr. 0·68 air-dry), lustrous ; straight-grained and medium-fine-textured with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by denser fibrous tissue, about 3 per cm. *Pores* small to very small, visible only under hand lens, moderately few (6–11 per mm.^{2}), evenly distributed, mostly solitary, occasionally roundish ; vessel lines inconspicuous. *Soft tissues* visible only under hand lens, in fine tangential lines, forming a network with the rays. *Rays* broad to very broad, prominent to the eye, widely spaced, evenly distributad ; radial flecks prominent.

Uses—Only locally used.

Material—

3368 Chittagong hill tracts (0·68).

10. XYLOPIA L.

A large genus of trees and shrubs widely distributed in the tropics but most numerous in Africa. The only species indigenous in India is dealt with here.

X. parvifolia Hk. f. & Th.—*kalpottan*, *santhu* (Mal.). A large straight tree, 24 m. in height and 45 cm. in girth. *Bark* pale yellowish-brown, smooth, 6 mm. thick.

Description of the wood

[Pl. **6**, 32]

General properties—Wood white to greyish-white, turning greyish-brown with age ; hard ; heavy (sp. gr. 0·77–0·82 air-dry) ; lustrous ; straight-grained and medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct delimited by darker coloured fibrous tissues, 4–6 per cm. *Pores* moderately

large, visible to the eye, but outlines may not be always clearly visible, few to moderately few, (6–12 per mm.^{2}), evenly distributed solitary or in radial multiples of 2–4. *Soft tissues* distinct only under the lens, in fine tangential lines, which are fairly evenly spaced, forming conspicuous network with the rays. *Rays* fine to very fine, indistinct to the eye, rather widely spaced but equidistant ; radial flecks distinct.

Bourdillon's experiments gave the value of P (the coefficient of transverse strength) = 725 and the weight 44 lb. per c. ft. (sp. gr. approx. 0·71). The timber is reported to be susceptible to borer attack.

Uses—It is suitable for light furniture, interior fittings and plywood.

Material—

* 4528 Travancore (0·77), 4597 Travancore (0·82).

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K. A. CHOWDHURY & K. N. TANDAN.

4. MENISPERMACEAE

A family of about 65 genera and 350 species of mostly twining vines, rarely erect shrubs or small trees, which occur cheifly in the tropics. Many members of the family are poisonous, some of which are used for poisoning arrows and darts. Fruits and roots of a few are also used in medicine. From the timber point of view the family is of no significance.

Of 17 genera and about 30 species, indigenous to the Indian region, all excepting one are climbers. The only species which reaches tree size is dealt with here.

COCCULUS DC.

Small trees or woody climbers, which are distributed in the tropical and sub-tropical regions of the world. Besides the species dealt with here, three more species of climbers have been reported to grow in the Indian region.

C. laurifolius DC.—*padma golancha* (Beng.), *kakra, tilpara* (Hind.), *dusaratiga* (Tel.). A large evergreen shrub or a small tree. *Bark* grey, smooth, very thin.

It is found in the sub-tropical Himalayas from Chamba to Nepal ascending to 1500 m., sub-Himalayan swamps in Assam, Anamalai hills, Shan states of Burma.

Description of the wood

[Pl. **6**, 33]

General properties—Wood greyish-white, turning pale brown on ageing; moderately hard; light to moderately heavy (sp. gr. 0·54–0·68 air-dry); straight to twisted-grained ; coarse and uneven-textured.

Gross structure—A diffuse-porous wood with islands of included phloem embedded in wavy concentric and sometimes irregular bands of soft tissues ("conjunctive tissue"). *Growth rings* appear to be delimited by thick bands of soft tissues 2–10 per cm. *Pores* small to very small, moderately numerous to numerous (13–40 per mm.^{2}), more or less evenly distributed, mostly solitary, round ; vessel lines indistinct. *Soft tissues* in broad wavy concentric bands ("conjunctive tissue"). *Rays* very broad, dividing the other woody tissues into small compartments, which taper towards the pith ; connection between rays of contiguous rings not apparent ; widely spaced ("interfasicular only"), evenly distributed ; radial flecks prominent.

Uses—It appears to be a suitable timber for inlaying and other decorative work where its beautiful figure can be utilized.

Material—

2466 Calcutta Bot. Garden (0·63), 2939 Sutlej valley (0·59), 4497 Dehra Dun (0·64), 4643 Dehra Dun (0·54), 5703 S. Coimbatore (0·68).

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S. K. PURKAYASTHA.

5. BERBERIDACEAE

A family of 10–12 genera and more than 200 species of small trees, spiny shrubs and herbs. They are mostly found in the north temperate regions of the world.

Economically members other than *Berberis* and *Podophyllum* are not of much significance. The rhizomes of *Podophyllum* are the source of the medicine podophyllin The bark and root of *Berberis* also contain alkaloids which are used in India for curing ulcers and sores. Fruits of both the genera are edible. From the point of view of agriculture, the best known species of the family is *Berberis vulgaris* L. It is the obligate host of the aecidial stage of wheat rust. The fine-textured wood of *Berberis* is sometimes used for the manufacture of small turnery articles and carvings; it also yields a yellow dye which is useful for colouring and tanning leather.

According to Chatterjee, the family is represented in India by six genera and about eighty-seven species, of which two genera, *Berberis* and *Mahonia*, have woody representatives. Both of them have been described here under *Berberis*.

BERBERIS L.
(including *Mahonia* Nutt.)

Small trees or shrubs distributed in the temperate regions of Asia, Europe, North America and the Andes mountains of South America. Of 81 species reported to grow in India, seven have been dealt with here.

Wood of various species of *Berberis* can not be distinguished with certainty. However, the single sample of *B. nepalensis* available for our study, may be separated from the rest. The difference is mainly in the arrangement and distribution of pores.

1. **B. angulosa** Wall.—*chutro* (Nep.). A shrub, 60 cm.–1·2 m. in height. *Bark* brown, soft, corky.

It is found in Kashmir, Nepal and Sikkim at 3,400 to 4,000 m. elevation.

Description of the wood—See page 34.

2. **B. aristata** DC.—*tsema* (Bhut.), *kingora* (Garh.), *darhald, kashmal, raswat* (Hind.), *kashmoi* (Jauns.), *bagi sutrum* (Kan.), *sumbul* (Kash.), *chathur, chitra, chotra, kilmora* (Kumaon), *chutro, matekisse* (Nep.), *chitra, kasmal, kasmi, kulsu, simlu, sumlu* (Punj.), *kammul, kashmal, kaumul* (Simla). Spinous shrub or small tree 2·5–5·5 m. high. *Bark* light brown, soft, corky.

It is found in the outer Himalayas from the Indus to Bhutan, at 1,200–3,400 m. elevation, in the Nilgiris and in Ceylon.

Description of the wood—See below.

3. **B. asiatica** Roxb.—*kingora* (Garh.), *kishornoi* (Jauns.), *kilmora* (Kumaon), *chutra*, *matekissi* (Nep.). A thorny shrub. *Bark* light brown, yellow inside, corky outside, deeply cleft vertically.

It is distributed in dry outer valleys of the Himalayas extending from Garhwal westwards to Bhutan at 1,000–3,400 m. elevation, and Parasnath hills, Chotanagpur.

Description of the wood— See below.

4. **B. coriaria** Royle (**B. aristata** DC.)—*kingora* (Garh.), *kashmoi* (Jauns.), *kashmal* (Simla). A tall shrub. *Bark* soft, corky.

It is found in the North-West Himalayas from Kulu to Kumaon at 2,400–3,000 m. elevation extending into inner valleys.

Description of the wood—See below.

5. **B. lycium** Royle—*kirmora* (Garh.), *chotroi* (Jauns.), *chochar*, *chotra*, *kashmal* (Simla). An erect shrub. *Bark* whitish to light grey, corky.

It occurs in the outer North-West Himalayas from Kashmir to Garhwal at 1,200–2,700 m. elevation.

Description of the wood—See below.

6. **B. nepalensis** Spr. (**Mahonia nepaulensis** DC.)—*kandlu*, *sharor* (Chamba), *khoru* (Jauns.), *dieng-phuh-rnong*, *dieng-niang-mat*, *dieng-soh-riang-mat-dynthoi* (Kh.), *lekchutra* (Nep.), *dieng-la-ranong*, *dieng-larnong* (Synt.), *maranthu* (Travancore). A shrub or a small tree 4·5–6 m. in height with a clear bole of 3–4·5 m. and 30–60 cm. in girth. *Bark* light brown, soft, corky.

It occurs in the outer Himalayas from the Ravi eastwards at 1,200–2,400 m. elevation, Khasi hills, Manipur, Burma hills and Nilgiris. But according to Chatterjee its distribution is confined to Nepal and adjoining areas.

Description of the wood—See below.

7. **B. vulgaris** L.—barberry. *chatroa* (Jauns.), *chamchur*, *chochar*, *kashmal*, *kembal*, *tutrum*, *zirishk* (Punj.). A thorny shrub. *Bark* greyish-brown, soft.

It is found in the North-West Himalayas from Nepal westwards at 2,400–3,700 m. elevation.

Description of the wood—See below.

Description of the wood

(*Berberis angulosa*, *B. aristata*, *B. asiatica*, *B. coriaria*, *B. lycium*, *B. nepalensis* and *B. vulgaris*).

[Pl. **6**, 34, 35]

General properties—Wood bright yellow, turning darker with age; hard to very hard; moderately heavy to very heavy (sp. gr. 0·62–0·98 air-dry usually straight-grained; fine to very fine-textured.

Gross structure—A ring-porous wood, but diffuse to semi-ring-porous in *B. nepalensis*. *Growth rings* distinct, demarcated by belts of larger early wood pores, except in *B. nepalensis* where they are delimited mostly by darker coloured fibrous tissue, 4–6 per cm. *Pores* except in *B. nepalensis*, of two distinct sizes, – moderately large and very small – the former just visible to the eye, few, solitary and in tangential or oblique multiples of 2–3 or in clusters, arranged in one or two concentric rows in the early wood; the latter just visible to indistinct under hand lens, numerous, in clusters arranged in flame-like and zig-zag patterns and also in short tangential or irregular lines; pores in *B. nepalensis* very small, just visible to indistinct under hand lens, numerous, usually in widely separated clusters of 3–5, sometimes with a tendency for arrangement in concentric rows in the early wood; vessel lines just visible to indistinct. *Soft tissues* not visible. *Rays* broad to very broad, widely spaced, evenly distributed, radial flecks prominent.

Uses—The wood is reputed to work and turn well. It is used for the manufacture of foot rules, picture frames, pattern work, carvings, toys, etc. The wood of *B. nepalensis* is used for *kukri* handles.

Material—

B. angulosa – 2862 Darjeeling (0·73).

B. aristata – 80 Simla (0·77), 2888 Simla (0·68), 3053 Simla (0·79), 3928 Nilgiris (0·75), 4420 Jaunsar, U.P. (0·74).

B. asiatica – 4456 Dehra Dun (0·86).

B. coriaria – 48 Simla (0·70), 2894 Simla (0·90), 3038 Simla (0·70), 3039 Simla (0·74), 3041 Simla (0·83), 3043 Simla (0·75), 4453 Jaunsar, U.P. (0·62), 4776 Tehri Garhwal (0·82), 3042 Simla (0·98).

B. lycium – 3054 Simla (0·73), 4810 Jaunsar, U.P. (0·80).

B. nepalensis – 2318 Darjeeling (0·78).

B. vulgaris – 3037 Simla (0·69), 3040 Simla (0·75).

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S. K. PURKAYASTHA AND R. SHAHI.

6. CAPPARIDACEAE

The caper family comprises of about 44 genera and over 1,000 species, mostly herbs and shrubs and a few small to medium-sized trees. They occur in the tropical and warm temperate regions of the world.

The family is not of much importance from economic point of view. The only articles of commerce are the capers, which are the dried or pickled buds of *Capparis spinosa* L. Several species are cultivated as garden plants and some are believed to be of medicinal value. A few species, also supply woods for local uses.

9 genera and approximately 50 species are indigenous to India. Of the 7 genera having woody representatives, two were not available for this study.

The colour of the woods varies from pale to deep yelllow to light brown. Anatomically the family can be divided into two main groups, on the basis of the presence or absence of included phloem. Growth rings are usually indistinct. Radial arrangement of the pores or pore-groups is often present but not clearly in *Capparis* (partly) and *Crataeva religiosa*. With the exception of *Cadaba trifoliata* and *Crataeva religiosa*, the Soft tissues are not always clearly visible under hand lens. Rays are broad to fine.

Key to the Genera

	Included phloem present ..	.. 1
	Included phloem absent ..	.. 3
1.	Tangential lines of parenchyma present	.. *Cadaba* (*C. trifoliata*)
1.	Tangential lines of parenchyma absent	.. 2
2.	Pores in long radial multiples ..	.. *Niebuhria* (*N. linearis*)
2.	Pores not in long radial multiples, mostly in radial or oblique pairs and occasionally solitary	.. *Maerua* (*M. arenaria*)
3.	Parenchyma distinctly visible under hand lens, aliform to aliform confluent	.. *Crataeva* (*C. religiosa*)
3.	Parenchyma indistinct to just visible under hand lens, vasicentric ..	.. 4
4.	Pores numerous, 36–39 per mm.^{2}	.. *Cadaba* (*C. indica*)
4.	Pores not numerous, 7–22 per mm.^{2}	.. *Capparis*

1. CADABA FORSK.

Mostly shrubs, distributed in the tropical and sub-tropical regions of Asia and Africa. Out of the three species reported to grow in the Indian region, two have been dealt with here.

1. **C. indica** Lamk. (C. farinosa Forsk)—*kodhab* (Hind.), *chengayiche*, *maragadegida* (Kan.), *katta katti* (Mal.), *habab*, *kalitaka*, *kalitakal* (Mar.), *diludu*, *veludhu*, *viti* (Tam.), *adamorinika*, *chemooda*, *chemoorda* (Tel.). A much-branched straggling shrub or a small tree. *Bark* brown, somewhat rough and thin with horizontal lenticels.

The plant is widely distributed in the dry places of the Punjab, Sind, Rajputana, Madhya Pradesh, Gujarat, Konkan, Karnatak and Andhra ; sometimes grows on other trees.

Description of the wood

[Pl. 6, 36]

General properties—Wood white turning light yellow on ageing ; hard ; moderately heavy to heavy (sp. gr. 0·70–0·88 air-dry) ; straight to slightly twisted-grained ; even and fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* small to very small, numerous to very numerous (31–45 per mm.^{2}) solitary or in radial or oblique pairs, arranged radially and separated by radial tracts of fibrous tissue devoid of pores, round to oval ; vessel lines just visible to the eye. *Parenchyma* vasicentric, indistinct to just visible under hand lens. *Rays* fine to very fine, closely spaced, evenly distributed. *Pith flecks* occasionally present.

Uses—It is a very fine-textured wood, suitable for the manufacture of turnery articles.

Material—

4152 Kistna, Andhra (0·70), 5595 Bellary (0·87), 5635 N. Coimbatore, Madras (0·88).

2. **C. trifoliata** (Roxb.) W. & A.—*chekonadi*, *kodikallu*, *konita*, *mallaguru*, *nallagara*, *peddasiva* (Tel.). A large shrub to small tree. *Bark* brown, slightly rough, very thin.

It occurs in the eastern Deccan and Karnatak and in the dry low countries of Ceylon.

Description of the wood

[Pl. 7, 37]

General properties—Wood white, turning light yellow on ageing ; moderately hard ; moderately heavy (sp. gr. 0·75 air-dry) ; slightly twisted-grained ; coarse-textured.

Gross structure—A diffuse-porous wood with thick concentric, wavy and sometimes irregular bands of *included phloem* alternating with dark coloured woody tissues. *Growth rings* indistinct. *Pores* small to very small, moderately

numerous to numerous (15–30 per mm.^{2}), usually crowded in the vicinity of the included phloem, solitary or in radial pairs, round ; vessel lines just visible to the eye. *Parenchyma* in thin tangential lines forming a network with the rays, distinctly visible under hand lens. *Rays* moderately broad, rather indistinct, widely spaced and evenly distributed.

Uses—At present only locally used.

Material—

5534 Cuddapah, Andhra (0·75).

2. CAPPARIS L.

A large genus of trees, shrubs and climbers distributed throughout the warmer parts of the world. About 40 species have been reported to grow in the Indian region, of which woods of seven species were available for study.

Woods of various species of *Capparis* can not be separated with certainty. The single sample of *C. grandis*, available for study, however, can be distinguished from the rest. The difference is mainly in the frequency of the pores and in the size and distribution of the rays.

1. **C. aphylla** Roth (**C. decidua** Pax)—*kari* (Bihar), *ker* (Guj.), *shiprigidda* (Kan.), *kera* (Mar.), *kher* (Marwar), *karil* (Punj.), *kiral* (Sind), *sanganchedi* (Tam.). A shrub or small tree up to 6 m. in height and 60 cm. in girth. *Bark* grey, corky with deep irregular cracks, 1·25 cm. thick.

It grows in dry arid regions of Uttar Pradesh, Punjab, Sind, Baluchistan, Rajputana, central and southern India.

Description of the wood—See page 39.

2. **C. divaricata** Hk. f. & Th. (**C. stylosa** DC.)—*revdi* (Kan.), *panchunda* (Mar.), *ambaram valli*, *porrivela*, *thuratti* (Tam.), *budarena budareni* (Tel.). A shrub or small tree. *Bark* brown, very rough, deeply cleft, 2·5 cm. thick.

It is found in the Deccan and Karnatak both on stony land and on black cotton soil and also in the dry districts of Ceylon.

Description of the wood—See page 39.

3. **C. flavicans** Wall. ex Kurz.—*saungkyan* (Burm.). A shrub, found in the drier parts of upper Burma.

Description of the wood—See page 39.

4. **C. grandis** L. f.—*pachar*, *pacharan* (Berar), *kaunggwa*, *kawgwa*, *khawkwa* (Burm.), *dhuti* (Guj.), *renapi*, *torate* (Kan.), *waghutty* (Mal.), *kauntel*, *pachoonda* (Mar.), *mudkondai*, *nakkulinjan*, *shudathoratti* (Tam.), *guli*, *nalluppi*, *oridonda*, *regguti* (Tel.). A shrub or small tree. *Bark* rough and corky, deeply and irregularly cracked, thick.

It occurs in Rajputana, Dharwar district, Chanda district, the Deccan, Eastern Ghats and Karnatak, Prome district in Burma and in the dry regions of Ceylon.

Description of the wood—See below.

5. C. horrida L. f. (C. zeylanica L.)—*gitoran* (Ajmere), *bagnei*, *kalokera* (Beng.), *nwamanithanbyet* (Burm.), *hins*, *his*, *jhiri*, *khalis* (Hind.), *tottula* (Kan.), *kanta*, *pripura*, *ulta kanta* (Kumaon), *govindi*, *gowidni*, *tarati*, *wag*, *wagutty* (Mar.), *bagnai* (Mong), *kentauni* (N. Chanda), *niphura*, *oseriva*, *oserwa* (Or.) *karallua* (Oudh), *his*, *karvila* (Punj.), *bagnei*, *bagni*, *baguchi*, *burnaseria* (Sant.), *aradanda* (Sind), *vennachi*, *welangiriya* (Sinh.), *adondai*, *marandan* (Tam.), *adonda* (Tel.). A thorny, climbing shrub. *Bark* yellowish-brown, rough, 6 mm. thick.

It is found all over India, Burma and Ceylon, usually in hedges or growing on other trees.

Description of the wood—See below.

6. C. olacifolia Hk. f. & Th.—*kota-har* (Asm.), *borun khosai*, *borun phitaphang* (Kach.), *deing-sia* (Kh.), *linguom* (Kuki), *jhenok* (Lep.), *ganga-thaisip* (Mechi), *hais*, *naski* (Nep.). A shrub up to 4·5 m. in height and 15–23 cm. in girth. *Bark* dark grey, corky or warty, 3 mm. thick.

It is found in sub-Himalayan tracts from Nepal to Assam, chiefly in the undergrowth of sissoo forests along rivers. Also in Andhra state and Shan hills of upper Burma.

Description of the wood—See below.

7. C. sepiaria L.—*kaliakara* (Beng.), *kanther* (Guj.), *gridhranakhi*, *kakadani*, *kundi* (Hind.), *hium garna*, *kantikapali* (Or.), *katan*, *kataran* (Rajasthan). A shrub or small tree. *Bark* thin, brown, often studded with thorns in pairs.

It occurs in the dry region throughout India, Burma, Ceylon and the Andamans, usually planted as a hedge plant.

Description of the wood—See below.

Description of the wood

(*Capparis aphylla*, *C. divaricata*, *C. flavicans*, *C. grandis*, *C. horrida*, *C. olacifolia*, and *C. sepiaria*)

[Pl. 7, 38]

General properties—Wood white, turning yellowish-brown on ageing ; hard ; moderately heavy to heavy (sp. gr. 0·56–0·91 air-dry) ; usually twisted or interlocked-grained ; medium-textured, but coarse in *C. grandis* and *C. horrida*.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct; when present the growth marks are usually due to fibrous bands, 3–9 per cm. *Pores* moderately large to very small, but of two distinct sizes in *C. horrida* and *C. grandis*, moderately few to numerous (6–30 per mm.^{2}), but few to moderately few (3–10 per mm.^{2}) in *C. grandis*, more or less evenly distributed, solitary or in radial multiples of 2–7, and occasionally in long radial chains as in *C. horrida*, round, sometimes filled with gummy deposits; vessel lines distinctly visible to the eye. *Soft tissues* vasicentric, indistinct to barely visible under hand lens. *Rays* fine to very fine, closely spaced, evenly distributed, but in *C. grandis* moderately broad and widely spaced, while in *C. sepiaria* and *C. horrida* (partly) moderately broad to fine and widely to fairly closely spaced; radial flecks present in the species having broader rays. *Traumatic gum canals* commonly present.

The timber is reported to be durable and resistant to termite attack.

Uses—"It is a hard and tough timber and is suitable for tool handles, cart wheels and axles, boat knee, etc. It can be used also locally for house building" (Chowdhury & Ghosh).

Material—

C. aphylla – 444 Ajmere (0·71), 3056 Multan (0·83).

C. divaricata – 5698 Nilgiris, Madras (0·91).

C. flavicans – 6473 Burma (0·77).

C. grandis – 1134 Ahiri Forest, M.P. (0·66).

C. horrida – 3244 Ajmere (0·73), 4650 U.P. (0·56), 4171 Kistna, Andhra (0·66).

C. olacifolia – 3297 Darjeeling (0·64), 3832 Ganjam (0·69).

C. sepiaria – 4157 Kistna, Andhra (0·72), 4649 U.P. (0·69).

3. CRATAEVA Forst.

A genus of trees widely distributed throughout the tropical regions of the world. Besides the species dealt with here, two more species have been reported to grow in the Indian region.

C. religiosa Forst.* (**C. nurvala** Buch-Ham. in part)—*barun* (Asm.), *barun, bonna, tiktoshak* (Beng.), *hatkom, kadat* or *kadet, konkadet* (Burm.), *nirujani* (Coorg), *jong-sia* (Garo), *barna, barua, bila, bilasi, biliana, varua, varvunna* (Hind.), *barana, varana* (Jeypore), *mibonju* (Kach.), *bitusi, hole lakki, nirvala* (Kan.), *ngasentur* (Kuki), *purbongnyok* (Lep.), *killi, nirmathilam, nirvalam* (Mal.), *hadwurna, karvam, Karwan, katshawri, kumla, kunda,*

* Recent researches have shown that *C. religiosa* Forst. does not occur in India. This name applies to a Polynesian species which is distinct from Indian species. There are two different plants which occur mixed in India. These are *C. nurvala* Buch-Ham. and *C. adora* Buch-Ham., referred to in the Flora of the British India as *C. religiosa* Forst. var. *nurvala* and *C. religiosa* var. *roxburghii* respectively.

nirvala, pilu, waiwurna (Mar.), *tailadu* (Mechi), *sibe-dotke* (Miri and Abor.), *chiple, chiplekath* (Nep.), *lunu-warana* (Sinh.), *varuna* (Sans.), *kudugi, mavalian, mavalingai, mavalingam* (Tam.), *ulimidi, urumatti, usiki, uskeman, uskia, voolemeri, vulimidi* (Tel.). A small to medium-sized tree, reaching occasionally up to 15 m. in height and 2·7 m. in girth. *Bark* dark grey with horizontal wrinkles, 1·25 cm. thick.

It is found throughout India, Burma and Ceylon chiefly near banks of streams.

Description of the wood

[Pl. 7, 39]

General properties—Wood yellowish-white to brown ; moderately hard to hard ; moderately heavy (sp. gr. 0·57–0·64 air-dry) ; straight-grained ; medium-coarse-textured.

Gross structure—A diffuse porous-wood. *Growth rings* indistinct. *Pores* small to moderately large, moderately numerous (10–15 per mm.^{2}), uniformly distributed, solitary or in radial pairs, occasionally also in oblique pairs, round to oval ; vessel lines inconspicuous. *Soft tissues* distinct under hand lens, aliform to aliform confluent. *Rays* moderately broad rather widely spaced, evenly distributed ; radial flecks often conspicuous.

Bourdillon's experiments in 1896 gave the value of P (the coefficient of transverse strength) = 279, but these were carried out with abnormally light wood. The wood is reported to season well but is not durable.

Uses—It is a good timber for turnery work and has been locally used for toys, cups and saucers and many other small articles.

Material—

565 Prome, Burma (0·64), 3115 Chanda (0·57).

4. MAERUA FORSK.

A genus of climbing shrubs which occur in tropical Asia and Africa. The only species reported from the Indian region is dealt with here.

M. arenaria Hk. f. & Th.—*vika* (Guj.), *pumichakeri* (Tam.), *puttatiga* (Tel.). A large climbing shrub. *Bark* yellow, reticulated.

It is found in western Himalayas, central India, dry regions of western India, Gujarat and throughout the Deccan.

Description of the wood

[Pl. 7, 40]

General properties—Wood white, turning light yellow on ageing ; moderately hard ; moderately heavy (sp. gr. 0·76 air-dry), straight to slightly twisted-grained ; coarse-textured.

Gross structure—A diffuse-porous wood. The important characteristic of this timber is the layers of *included phloem* in narrow wavy concentric and occasionally irregular bands alternating with darker zones of wood. *Growth rings* indistinct. *Pores* moderately large to small, moderately numerous to numerous (15–30 per mm.^{2}), mostly in radial or oblique pairs, occasionally solitary, radially arranged and separated by radial tracts of fibrous tissue devoid of pores; vessel lines just visible to the eye. *Soft tissues* indistinct. *Rays* fine to moderately broad, widely spaced; like other timbers having included phloem, it often shows a pleasant figure on the longitudinal surface.

Uses—It is at present locally used. It may, however, be tried for inlay work, where its beautiful figure could be utilized.

Material—

5637 N. Coimbatore, Madras (0·76).

5. NIEBUHRIA DC.

A genus of trees and shrubs found in tropical Asia and Africa. The species dealt with here is the only one reported to grow in India.

N. linearis DC. (**N. apetala** Dunn.)—*thurutti iruvalli* (Tam.). A small tree. *Bark* brown, granular, thin. It is found in the hilly parts of Karnatak.

Description of the wood

[Pl. 7, 41]

General properties—Wood white, turning light brown with age; moderately hard; moderately heavy (sp. gr. 0·67 air-dry); interlocked-grained; coarse-textured.

Gross structure—A diffuse-porous wood. The most important characteristic of this timber is the thin wavy concentric and occasionally irregular bands of *included phloem*. *Growth rings* indistinct. *Pores* small to very small, moderately numerous (11–15 per mm.^{2}), usually in widely apart, radial multiples of 2–8, round to oval; vessel lines just visible to the eye. *Soft tissues* indistinct. *Rays* fine to very fine, closely spaced, evenly distributed; on the longitudinal surface the timber shows a pleasant figure due to the presence of *included phloem*.

Uses—In addition to its present local use, it may be tried for inlay work.

Material—

5535 Cuddapah, Andhra (0·67).

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S. K. PURKAYASTHA AND M. H. KAZMI.

7. FLACOURTIACEAE

A family of over 80 genera and 800 species of woody plants which are widely distributed in the tropics and subtropics.

The most important product of this family is chaulmoogra oil, used in the treatment of leprosy. It is obtained from the seeds of *Hydnocarpus wightiana* Bl. and *Taraktogenos kurzii* King [*Hydnocarpus kurzii* (King) Warb.]. The seeds of several species of *Hydnocarpus* yield an oil having similar properties. Fruits of *Flacourtia* and a few other genera are edible.

From the timber point of view, the family is not of much importance. The Venezuelan boxwood or zapatero, the only timber which is well known as a substitute for boxwood, is obtained from *Casearia praecox* Griss. In the Indian region the Burma lancewood, *Homalium tomentosum* Benth., is used for shafts of heavy carts, masts and for constructional purposes ; other timbers are mostly used locally as building material while a few, e.g., *Casearia* and *Hydnocarpus*, are used for the manufacture of turnery articles.

In India the family is represented by 10 genera. Except *Ryparosa* Bl. all have been dealt with here. The wood varies in colour from yellowish-grey to various shades of brown. It is, as a rule, moderately hard to hard, moderately heavy to heavy and fine-textured, but usually very hard and very heavy in *Flacourtia*, *Homalium* and *Scolopia*. Anatomically the family is very uniform. The wood is characterised by absence or very scanty development of soft tissues which are not visible under hand lens. The pores are small to very small, either solitary or in short radial multiples and often show radial alignment. The rays are fine to very fine and closely spaced except in *Casearia*.

All the genera show almost similar anatomical structure. *Casearia* is only slightly different because of its ray width.

1. ASTERIASTIGMA Bedd.

It was a monotypic genus which has now been included by Systematists under *Hydnocarpus*.

A. macrocarpa Bedd. [**Hydnocarpus macrocarpus** (Bedd.) Warb.]. Two sub-species have been recognized by Sleumer, sub-sp. *malabarica* growing in Travancore and sub-sp. *burmanica* found in Burma.—*ailiyam*, *malaimargavetti malankummatti* (Mal.), *vellanangu* (Tam.). A large tree 21 m. in height and 45 cm. in diameter.

Description of the wood

General properties—Wood grey turning light brown on ageing ; moderately hard ; moderately heavy (sp. gr. 0·57 air-dry) ; straight to slightly twisted grained ; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by darker bands of fibrous tissue, 4 per cm. *Pores* small, just visible to the naked eye, numerous (25–32 per mm.^{2}), evenly distributed, solitary or in radial multiples of 2, occasionally up to 4, radially arranged, roundish, open or plugged with whitish powdery deposits ; vessel lines distinct but not conspicuous. *Soft tissues* not visible. *Rays* fine to very fine, indistinct to the eye, closely spaced and evenly distributed.

Bourdillon gives the value of P (co-efficient of transverse strength) = 456 and weight 48 lb. per cft. (sp. gr. app. 0·77).

Uses—According to Bourdillon, the timber is "useless, but as it is obtainable in straight lengths, it is sometimes employed for rough huts for temporary occupation".

Material—

4689 Travancore (0·57), 6408 Burma (0·57).

2. CASEARIA Jacq.

A genus of trees and shrubs widely distributed in the tropics. In the Indian region about 8 species are reported to grow, of which 3 were available for study. Their wood is indistinguishable.

1. **C. esculenta** Roxb.—*bolduiagreng* (Garo), *doddahanise* (Kan.), *dieng-soh-lormao* (Kh.), *malamapavatta, pannimurunga, vella-kunnan* (Mal.), *kalkulta, morei* (Mar.), *kron-suri-arong* (Mik.), *kakkaipalai, kottargovai* (Tam.). Usually a large shrub, but may attain tree size, up to 21 m. in height and 45 cm. in diameter.

It occurs in the western coast from Konkan southwards, hills of Western Ghats up to 1,200 m., Andhra, hills of Assam, and in Burma (Tenasserim).

Description of the wood—See page 46.

2. **C. glomerata** Roxb.—*tel-burki* (Asm.), *rawit* (Berar), *nara, narha,* (Dehra Dun), *kakri* (Dotial), *nara, phempri* (Garh.), *boldreng, bol-dujareng, bolong-maindok* or *maindop,* or *maindot* (Garo), *girchi* (Gon.), *chilla, kathera, naro, pimpri* (Hind.), *konje* (Kan.), *beri* (Kharw.), *dieng-chi-dohkha, kachidohkka, sia-dokha* (Kh.), *reri* (Kol), *veska* (Koya), *karo-an* (Kuki), *nar pinpriya, narra* (Kumaon), *rewat* (Kurku), *tanki, telingkung* (Lep.), *bokhada, kurdan, safed karai* (Mar.), *datphenda, dukhenda* (Mechi), *han-bo-akarang* (Mik.), *barkaunte* (Nep.), *giridi* (Or.), *newri* (Sant.), *khelrel-thing* (Tipp.). A large shrub occasionally growing up to a middle-sized tree, 12–18 m. in height with a clear bole of 6–9 m. and 1·8–2·4 m. in girth. *Bark* greyish brown, rough, thin.

It is found in the "Sub-Himalayan tract ascending to 2,100 m. from Chenab eastwards, in Sikkim, Assam and Burma, Oudh and Central India, Konkan and

Deccan Ghats in open situations; ascends to 1,200 m. in Khandesh Akrani" (Talbot).

Description of the wood—See below.

3. **C. tomentosa** Roxb.—*maun* (Beng.), *tordul* (Bhil), *tondri, tundri* (Gon.), *bairi banbheri, beri, bhains ber, bhari, bheri, chilara, chilla, churchu* (Hind.), *biliyubina, hlingi, konje* (Kan.), *beri* (Kharw.), *rore* (Kol.), *kesa* (Kurku), *bokhade, karei, lainja, massei, modgi, modi* (Mar.), *girari, kokra* (Or.), *charcho* (Sant.), *kadichai* (Tam.), *der* (Th.), *charcho, chilakadiddi* (Tel.). A shrub sometimes a small tree. *Bark* whitish in colour, 8 mm. thick.

It is found in the sub-himalayan tract from the Indus eastwards ascending to 900 m. in central, western and South India.

Description of the wood—See below.

Description of the wood

(*Casearia esculanta, C. glomerata*, and *C. tomentosa*)

[Pl. 8, 48]

General properties—Wood yellowish-white, turning light brown on ageing; moderately hard to hard; moderately heavy to heavy (sp. gr. 0·58 to 0·82 air-dry); straight to twisted-grained; fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker coloured fibrous tissues, 3–9 per cm. *Pores* small, just visible to the eye, numerous (21–36 per mm.^{2}), evenly distributed, mostly in radial pairs, or in radial multiples of 3–5, radially aligned, oval; vessel lines inconspicuous. *Soft tissues* not visible. *Rays* moderately broad to very fine, closely spaced and evenly distributed.

Bourdillon's experiments with *C. esculenta* gave the value of P (the Coefficient of transverse strength) = 965 and weight 56 lb. per c. ft. (sp. gr. approx. 0·90), and according to him it is liable to split, but resistant to borer attack.

Uses—The timber is mostly used as a building material. It is suitable for the manufacture of small turnery articles like toys, combs, etc.

Material—

C. esculenta – 4723 Travancore (0·82), 6613 Burma (0·77).

C. glomerata – 691 Darjeeling (0·68), 2381 Darjeeling (0·66).

C. tomentosa – 1183 Ahiri Reserve, M.P. (0·57), 1363 Gonda, U.P. (0·61), 2802 Melghat, M.P. (0·52), 3085 Gonda, U.P. (0·58), 3089 Kheri, U.P. (0·62), 3527 Khurda Forests, Orissa (0·64), 6718 Dehra Dun (0·66).

3. FLACOURTIA COMMERS.

Trees or shrubs distributed in the tropical regions of Asia and Africa. Of about 7 species known to grow in the Indian region, two were available for study. Woods are indistinguishable.

1. **F. cataphracta** Roxb. ex Willd. [**F. jangomas** (Lour) Raeusch.]—*goch-poniol, phinel, polian, ponial* or *poniol* (Asm.), *beunch, paniala* (Beng.), *naywe* (Burm.), *luk-luki, tokroi* (Cach.), *darichik* (Garo), *jamuna, pachnala, paniala, panialah, talispatri* (Hind.), *abblu, shamper* (Kan.), *dieng-soh-mluh* (Kh.), *kanji, thailira, vayantatha* (Mal.), *phonial* (Mechi), *thengpi-kundu-arong* (Mik.), *baincha* (Or.), *luk-luki, tokroi* (Sylh.), *charalu, mullumukanchi, vayang karei* (Tam.), *duk-duki* (Tipp.), *paniyara* (Oraon). A small to medium-sized tree up to 9–15 m. in height with a clear bole of 3–9 m. and 90 cm.–1·5 m. in girth. *Bark* rusty brown, smooth, thin.

It is found in the moist forests of Dehra Dun and also throughout Bengal, Chota Nagpur, Assam and Chittagong, South India and Burma but rather scarce. Often cultivated for fruits.

Description of the wood—See below.

2. **F. ramontchi** L'Herit [**F. indica** (Burm. f.) Merr. (in part)]—*benchi, katai, tambat* (Beng.), *gatgoti, gorgrhoti, kalkai, perbekat* (Berar), *bhorkhakai* (Bhil), *naywe* (Burm.), *kakein* (M.P.), *bilangra, bilangur, kanel* (East Almora), *bilagura* (Garh.), *bench, bhanber, bilangoa, kandi, kango, kanju, kanker, katahi, kattar, katti, swandu kantaka* (Hind.), *kangori* (Jeypore), *bhably, gajale, hanmunki, hanumanth* (Kan.), *sapka* (Khond.), *merlo* (Kol.), *kala-kandei* (Kumaon), *benti* (Mal Pahari), *bhaekal, kaker, paker* (Mar.), *kaikun, khakeran* (Merwara), *bali-bhaincho, kontadhawra, kontai kuli, mamuri, serali* (Or.), *katail* (Palamow), *katia* (Sans.), *marle* (Sant.), *ugurassa* (Sinh.), *chothakilai, kattukala, katukali, kothuvela* (Tam.), *gandregu, giamehetu, kaka kanregu, kondagogu, nakka-naregu, puli-eliki, puthikithada* (Tel.). A large shrub but under favourable conditions may be a medium-sized tree. *Bark* grey, scaly, thin.

It is found throughout India on dry hills, in deciduous, monsoon and thorn forests, and in Prome district of Burma and also in Ceylon, the Malay Archipelago and Madagascar, sometimes cultivated.

Description of the wood—See below.

Description of the wood

(*Flacourtia cataphracta* and *F. ramontchi*)

[Pl. 7, 42]

General Properties—Sapwood light brown, gradually merging into chocolate brown heartwood ; very hard ; heavy to very heavy (sp. gr. 0·76 to 1·13 air-dry) ; straight to twisted grained ; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct; demarcated by darker coloured fibrous tissue, 3–8 per cm. *Pores* small to very small, just visible to the eye, moderately numerous (15–17 per mm.^{2}), evenly distributed, mostly in radial multiples of 2–3, occasionally up to 6, radially aligned, roundish; vessel lines just visible to the eye. *Soft tissues* not visible. *Rays* fine to very fine, closely spaced and evenly distributed.

Bourdillon gives the value of P (the Coefficient of transverse strength) = 811 and weight 56 lb. per cft. (sp. gr. approx. 0·90) for *F. cataphracta*. Troup states that *F. ramontchi* splits but does not warp and is durable. It takes a good polish.

Uses—It is used for posts and poles, agricultural implements and for the manufacture of turnery articles. It is said to be good in resisting friction and might be used for pulleys.

Material—

F. cataphracta – 4511 Dehra Dun (0·87), 4631 Travancore (0·88), 6347 Burma (1·13).

F. ramontchi – 260 Garhwal (0·76), 460 Ajmere (0·79), 2739 Moharli Reserve, M.P. (0·77), 3125 Burma (0·91).

4. GYNOCARDIA R. Br.

A monotypic genus.

G. odorata R. Br.—*sibe-tulpi, sibe turpu* (Abor.), *umphu* (Aka.), *bandarpele, bonsha, chaulmugra, lemten* (Asm.), *chaulmaugra, chaulmugri, petarkura* (Beng.), *joungpung* (Burm.), *takik-change* or *takuk change* (Duff.), *balibu, masribu, pha-bipha, thitho* (Garo), *dieng-soh-liang, dieng-soh-phailing, soh-pheeling* (Kh.), *koitur, thei-shong-pung* (Kuki), *juk, jul-kung* (Lep.), *koitur* (Lush.), *althaiba, khungkha-bighang, thai-alokhrong, thaila-phrong-baphang* (Mechi), *kampi-tumtal-arong, thebong-kok* (Mik.), *jaki pomju-asing, sibe-turpu, taki-sidik* (Miri.), *bandre* or *gante* or *ramphal, kadu* (Nep.). A moderate-sized tree, 9–15 m. in height with a clear bole of 3–6 m. and 90 cm.–1·5 m. in girth. *Bark* grey, smooth, 6 mm. thick.

It is found in the northern and eastern Bengal, Assam and Burma.

Description of the wood

[Pl. 8, 43]

General properties—Wood yellowish-grey to light brown, soft to moderately hard, light to moderately heavy (sp. gr. 0·49–0·71 air-dry); straight to interlocked-grained; medium to fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by bands of fibrous tissue, 2–4 per cm. *Pores* moderately large to small, numerous, in radial multiples of 2–3, occasionally up to 6, sometimes solitary, evenly distributed, round or oval; vessel lines distinct to just visible to the eye. *Soft tissues* not visible. *Rays* fine to very fine closely spaced and evenly distributed.

Seasoning—The timber is reported to season well but the process is slow. For best results, it must be converted immediately.

Natural durability—It is reported to be fairly durable.

Insect attack—Dry wood is liable to be attacked by the borer, *Stromatium barbatum* Fabr. Fam. Cerambycidae, order Coleoptera.

Working qualities—Easily sawn when green, but more difficult to convert after seasoning. On the lathe, it turns well and finishes to a good surface, but it is not a typical turnery wood.

Supply and uses—Limited supplies are available from Cachar and Lakhimpur in Assam, where it is used locally as house posts and wall boards. It is a good constructional timber for general purposes, especially for planking.

Moterial—

708 Chittagong (0·72), 6177 Kurseong (0·49).

5. HOMALIUM Jacq.

Trees and shrubs widely distributed in the tropics. About 10 species are indigenous to India and Burma, of which five are dealt with here.

1. **H. bhamoense** Cubitt and Smith—*bolong sajira* (Asm.), *boldu-jag-reng, bolong-wah-vthri, shokshimarong* (Garo). A tall tree found in Burma (Bhamo), two varieties have also been reported from Assam, Sikkim and Chittagong. Kanji Lal and Das consider that *H. bhamoense* constitutes a north-eastern race of *H. zeylanicum* Benth.

Description of the wood—See page 50.

2. **H. grandiflorum** Benth.—A middle-sized tree found in Burma (Mergui).

Description of the wood—See page 50.

3. **H. minutiflorum** Kurz.—A tree of lower Burma.

Description of the wood—See page 50.

4. **H. tomentosum** Benth.—Burma lancewood. *mai-kan-ang, myaukchaw, myaukngo, thewalaw* (Burm.). A large tree 24–27 m. in height with straight cylindrical clear bole of 12 to 15 m. and 2·4–3 m. in girth. *Bark* white, smooth, thin.

It is a very common tree all over Burma and scattered in Chittagong and in the Ganjam district.

Description of the wood—See below.

5. **H. zeylanicum** Benth.—*kalmattiga* (Kan.), *kalladamba, kaluvaluka, manthola mukki* (Mal.). A large straight tree up to 30 m. in height and 60 cm. in diameter. *Bark* pale, rough, 1·7 cm. thick.

It is found in evergreen forests of the Western Ghats from North Kanara southwards, up to 900 m. ; also in Ceylon.

Description of the wood—See below.

Description of the wood

(*Homalium bhamoense, H. grandiflorum, H. minutiflorum, H. tomentosum*, and *H. zeylanicum*)

[Pl. 9, 49]

General properties—Heartwood usually indistinct, wood greyish-brown to pale reddish-brown ; hard to very hard ; mostly heavy to very heavy (sp. gr. 0·67–0·99 air-dry) ; straight-grained ; usually fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker bands of fibrous tissue 2–8 per cm. *Pores* small, indistinct or just visible to the eye, usually numerous (17–35 per mm.^{2}), but slightly larger and fewer in *C. zeylanicum* (11–21 per mm.^{2}), evenly distributed, in radial multiples of 2–3 or solitary, roundish, sometimes filled with yellowish gummy deposits ; vessel lines just visible to distinctly visible. *Soft tissues* not visible. *Rays* fine but usually distinct due to whitish deposits, closely spaced and evenly distributed.

Strength—Only *H. tomentosum* has been subjected to full scale tests. For strength figures see appendix I.

Bourdillon's experiments with *H. zeylanicum* gave the value of P (Coefficient of transverse strength) = 777 ; and the weight 56 lb. per cft. (sp. gr. approx. 0·90).

Seasoning—*H. tomentosum* is a very difficult timber to season. It develops serious end splits and surface cracks and also warps, twists and shrinks badly. Kapur states that girdling the trees before felling, green conversion and slow seasoning would perhaps give good results. Some kind of end paint and cutting the stock to small dimensions has also been recommended. *H. zeylanicum* is also reported to be refractory to seasoning.

Natural durability—The wood of *H. tomentosum* is not durable ; it lasts for 46 to 64 months. Lewis states that *H. zeylanicum* is very durable.

Insect attack—According to Bourdillon the wood of *H. zeylanicum* is not susceptable to borer attack.

Preservative treatment—Heartwood of *H. tomentosum* is treatable, but complete penetration cannot be always obtained.

Working qualities—*H. tomentosum* "is very hard and difficult to saw, especially when seasoned. It works, both by hand and on a machine to a very smooth surface and takes polish well. It also turns well on a lathe requiring very little hand finish" Pearson & Brown.

Supply and uses—The Burma lance wood is available in fair qunatities from Burma. No information is available on other species. It is used for mast, for boat, and house building and also sometimes for furniture. It is preferred for shafts of heavy carts. *H. tomentosum* is an excellent firewood and said to be rivalled only by *Heritiera fomes*.

Material—

H. bhamoense – 6829 Burma (0·84).

H. grandiflorum – 6792 Burma (0·99).

H. minutiflorum – 6800 Burma (0·75).

H. tomentosum – 331 Burma (0·97), 2534 Burma (0·71), 2699 Tavoy (0·94), 2702 Tavoy (0·84), 3921 Ganjam (0·67), 4501 (0·73), 5273 Toungoo, Burma (0·90), 5274 Toungoo, Burma (0·92), 5768 Tenasserim, Burma (0·84), 5838 Burma (0·95), 6509 Burma (0·98).

H. zeylanicum – 4678 Travancore (0·89).

6. HYDNOCARPUS

A genus of trees found in India and in South-East Asia. All the three species reported to grow in the Indian region, have been dealt with here. Anatomically these are indistinguishable. However, *H. alpina* stands out from the remaining two, because of its heavy and fine-textured wood.

1. **H. alpina** Wt.—*maratalti* (Badaga), *sanua solti* (Kan.), *malmurutti*, *maravetti* (Mal.), *athuchangalai*, *attuchankalai*, *koranguthalai*, *maravetti* (Tam.), *muchathunika* (Tel.). A small to medium-sized tree with a clear bole of 6 to 9 m. and 90 cm. to 1·2 m. in girth in Tinnevelly district, to 2·5 m. bole and 60 to 90 cm. in girth in Kunoor, the stem is often grooved and fluted and not very straight. *Bark* greyish brown, slightly rough, 6 mm. thick.

It occurs in the hill forests of Western Ghats from South Kanara to Travancore up to 1,800 m., – also in Ceylon.

Description of the wood—See below.

2. **H. anthelminthica** Pierre and C. E. C. Fisher (**H. castanea** Hk. f. & Th.). A middle-sized tree 7·5–12 m. in height and 60 cm.–1·2 m. in girth. *Bark* grey.

It is found in the Andamans and in Burma (Tenasserim and Mergui).

Description of the wood—See below.

3. **H. wightiana** Bl. [**H. laurifolia** (Denn.) Sleum.]. *kauti*, *kava* (Bombay), *kosto* (Goa), *bhuthahi*, *garuduphala*, *niradi-vittulu*, *surante*, *torotti* (Kan.), *konstel*, *konxtii* (Konkani), *kodi*, *koti*, *maravetti*, *maroti*, *niralam*, *nirvetti*, *tamana*, *vetti* (Mal.), *kadu-kavata*, *kantel*, *kastel*, *kiti*, *kobasel*, *kowti* (Mar.), *garudaphala* (Sans.), *maravattai*, *maravetti*, *niradimuttu* (Tam.), *adavi-badamu*, *niradi*, *niradi-vettulu* (Tel.), *surante* (Tulu). A moderate-sized to large tree up to 30 m. in height and 75 cm. in diameter. *Bark* pale brown with white marks, smooth, thin.

It is common along the Western Ghats from Konkan southwards ascending to 600 m., also below the Ghats in Malabar and Kanara.

Description of the wood—See below.

Description of the wood

(*Hydnocarpus alpina*, *H. anthelminthica* and *H. wightiana*)

[Pl. 8, 44, 45]

General properties—Wood yellowish-grey to pale brown: in *H. anthelminthica* and *H. wightiana* soft to moderately hard and light to moderately heavy (sp. gr. 0·51–0·63 air-dry), but hard and heavy (sp. gr. 0·77–0·79 air-dry) in *H. alpina*; usually straight-grained, but curly-grained in one sample of *H. alpina*; fine to very fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker coloured fibrous tissue, 3–6 per cm. *Pores* not visible (*H. alpina*) or just visible to the eye, numerous to very numerous (26 to 62 per mm.^{2}), evenly distributed, for the most part in radial multiples of 2–4, aligned radially, roundish; vessel lines just visible or not visible to the eye. *Soft tissues* not visible. *Rays* fine to very fine, closely spaced and evenly distributed.

Strength—Bourdillon gives the value of P (the Coefficient of transverse strength) = 464 and weight 36 lb. per cft. (sp. gr. approx. 0·58) for *H. wightiana*. Other species have not yet been tested for strength.

Seasoning—*H. alpina* is said to be a somewhat difficult timber to season. It develops fine, straight, end-splits and also is liable to crack on the surface in fine wavy lines. It should be converted green and stored under cover in open

stacks. *H. wightiana*, however, seasons without cracking but is very liable to warp.

Natural durability—Not durable; *H. alpina* is reported to be fairly durable under cover. *H. wightiana* is susceptable to discoloration.

Working qualities—It saws and works to a very smooth surface.

Supply and uses—*H. alpina* is available in small quantities from Tinnevelly and Kunoor divisions and limited supplies of *H. wightiana* are available from Kanara, Mangalore district and Malabar. The timber appears to be very little used at present. Pearson and Brown state that *H. alpina* is used for constructional purposes on the west coast and recommend that it should be tried for pattern work, foot rules, picture frames, mouldings and carvings. *H. wightiana* is suitable for match splints.

Material—

H. alpina – 5644 Nilgiris (0·77), 6087 Nilgiris (0·79), 6401 Palghat (0·77).

H. anthelminthica – 6828 Burma (0·63).

H. wightiana – 4529 Travancore (0·50), 4712 Travancore (0·58), 6064 S. Kanara (0·61), 6334 S. Mangalore (0·53).

7. SCOLOPIA SCHREB.

A genus of trees and shrubs found in the tropics of the old world. Four species have been recorded in India and Burma; *S. crenata* Clos., a middle-sized tree, is found in the Western Ghats in all hill districts above 600 m. and in the Andaman islands; *S. gaertneri* Thwaites and *S. schreberi* Gmel. are trees of Travancore, and *S. roxburghii* Clos. occurs in Burma (Mergui). None of these were available for study. The specimen described here was originally collected by Kurz. from the Andamans and identified by him as *S. rhinanthera*. But since then nobody else has recorded its presence in those islands.

S. rhinanthera Clos.—A small tree found in Malay Peninsula on or near the coast; also in Andamans (?).

Description of the wood

[Pl. 8, 46]

General properties—Wood dark reddish-brown; very hard; very heavy (sp. gr. 1·10 air-dry); twisted-grained; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker bands of fibrous tissue, about 4·5 per cm. *Pores* small to very small, clearly visible under hand lens, numerous (22–31 per $mm.^2$), evenly distributed, mostly in radial multiples of 2, occasionally up to 4, radially aligned,

round ; Vessel lines visible but not distinct. *Soft tissues* not visible. *Rays* fine to very fine but distinct due to the lighter colour of the rays, closely spaced and evenly distributed.

Uses—According to Burkill, the timber is used for house-building. Troup states that *C. crenata* is used for planking.

Material—

1969 Andamans (1·10).

8. TARAKTOGENOS HASSK.

A genus of trees found in India and South-East Asia. The only species reported from the Indian region is dealt with here.

T. kurzii King [**Hydnocarpus kurzii** (King) Warb.]—*kirta-kirpang, taloasing* (Abor.), *lamtem* (Asm.), *chaulmugra, dalmugri* (Beng.), *kalasuo, kalaw* (Burm.), *balibu* (Garo), *serbuli* or *shailoukrong buphang* (Kach.), *dieng-soh-lap* (Kh.), *matta* (Lush. & Tipp.), *uthou* (Manip.), *thibongthar* (Mik.), *siri-asing* (Miri), *rowai-thing* (Naga), *bandre* (Nep.). A tree 12–15 m. in height. *Bark* grey, brown or almost black, fairly smooth.

It is found in the evergreen forests of Assam, Chittagong hill tracts and Burma.

Description of the wood

General properties—Wood light brown ; moderately hard ; moderately heavy (sp. gr. 0·64–0·68 air-dry) ; straight-grained ; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* small to very small, indistinct to the eye but distinctly visible under hand lens, numerous to very numerous (28–51 per mm.^{2}), evenly distributed, usually in radial multiples of 2–4, occasionally solitary, aligned radially, round ; vessel lines visible but inconspicuous. *Soft tissues* not visible. *Rays* fine to very fine, closely spaced and evenly distributed.

Uses—The timber is likely to be suitable for the manufacture of match, packing boxes, etc.

Material—

5719 S. Tenasserim, Burma (0·68), 6307 Burma (0·64).

9. XYLOSMA

A genus of trees and shrubs very similar to *Flacourtia* distributed throughout the warmer parts of the world. 3 species have been reported to grow in India, only one of which was available for study.

X. longifolium Clos.—*katahar, kata-holi, kata-ponial, mota-koli, mota-puli* (Asm.), *hagrani-sa* (Cach.), *phalama* (Garh.), *phul-wal* (Garo), *dandal, kaltawa, katari, katpatia, khandhara, sialu* (Hind.), *dandal, katai* (Kharw.), *dieng-kani* (Kh.), *thengpianiarong* (Mik.), *tang-en-ising, uli-tangasing* (Miri), *cherinda, cherundi, chirunda, chopra, drendu* (Punj.). A moderate-sized to large tree up to 18 m. in height and 1·2 m. in girth. *Bark* grey, rough, thin, thorny when young.

It occurs in North-West Himalaya ascending up to 1,500 m., Assam, Burma, Chota Nagpur, Andhra.

Description of the wood

[Pl. 8, 47]

General properties—Wood light brown, moderately hard, moderately heavy to heavy (sp. gr. 0·72–0·76 air-dry); straight to twisted-grained, fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker bands of fibrous tissue, 3–4 per cm. *Pores* small, indistinct to just visible to the eye, numerous (23–36 per mm.^{2}), evenly distributed, mostly in radial multiples of 2, occasionally up to 4, with a tendency for radial alignment, roundish; vessel lines inconspicuous. *Soft tissues* not visible. *Rays* fine to very fine, closely spaced evenly distributed.

Uses—It is mostly used locally for house posts and fence posts.

Material—

5005 Dehra Dun (0·72), 6650 Burma (0·76).

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S. K. PURKAYASTHA

8. PITTOSPORACEAE

A small family of about 9 genera and 200 species of trees, shrubs and climbers. All the genera excepting *Pittosporum* are endemic in Australia.

The family is of little economic importance but it includes some ornamental plants, having fragrant and showy flowers. The resin or oleoresin present in the bark of some species of *Pittosporum* is reputed to be of medicinal value and believed to be an antidote to snake-poison. The only genus *Pittosporum* which grows in India is dealt with here.

PITTOSPORUM BANKS

A genus of trees, shrubs and climbers distributed in the tropical and sub-tropical regions of the world, mostly in Australia, also in Indo-Malayan region and South Africa. In the Indian region about 8 indigenous and exotic species have been reported to grow, of which 3 are described here. The woods are indistinguishable.

1. **P. eriocarpum** Royle—*garshuna, gar-silung, meda tumri* (Hind.), *agni, raduthia* (Kumaon), *kakria* (Nep.). An evergreen shrub or small tree with a short trunk up to 6 m. in height, and 1·2 m. in girth. *Bark* silvery grey with prominent horizontal lenticels.

It is found in outer ranges of Himalayas from Punjab to Sarda at 900–2,000 m. elevation.

Description of the wood—See page 58.

2. **P. floribundum** W. & A.—*devsan* (Bihar), *tumri* (Garh.), *dieng-dum, dieng-mulo-shi-ing, dieng-si-ing* (Kh.), *raini* (Kumaon), *bongzam, prongzam* (Lep.), *vehyenti, vekhali, vikhari, vekadi* (Mar.), *tibilti* (Nep.). A small to medium-sized tree 7·5–12 m. in height, with a short trunk up to 1·8 m. in girth. *Bark* grey, with prominent horizontal lenticels which are 1·3 cm. long, very thin.

It occurs in sub-Himalayan tract from Garhwal to Sikkim, Khasi hills, Shan hills, upper Burma and Western Ghats from Konkan to Nilgiris at 900–1,200 m. elevation.

Description of the wood—See page 58.

3. **P. tetraspermum** W. & A.—*kaccha patti* (Mal.). A small tree with a thick trunk. *Bark* greyish-brown, thickly studded with yellow lenticels, in bundles of 3–4, peeling off in small flakes, thin.

It grows in Western Ghats in Shola forests above 1,500 m. from Nilgiris to Travancore, also in Ceylon.

Description of the wood—See below.

Description of the wood

(*Pittosporum eriocarpum*, *P. floribundum* and *P. tetraspermum*)

[Pl. 9, 50]

General properties—Wood whitish-brown, lustrous, moderately hard; moderately heavy (sp. gr. 0·68–0·74 air-dry); usually straight-grained, fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct delimited by denser bands of fibrous tissue, 3–4 rings per cm. *Pores* small, numerous to very numerous (36–41 per mm.^{2}), evenly distributed, mostly in radial multiples of 3–5, occasionally in radial chains, or in clusters of 2–6, occasionally filled with yellowish deposits; vessel lines visible but not conspicuous. *Soft tissues* usually indistinct but when visible appear as a thin line round the pores or pore-groups. *Rays* moderately broad, distinct to the naked eye, standing out prominently as white lines against darker coloured background, closely spaced and evenly distributed. *Pithflecks* occasionally present.

The dry wood of *P. eriocarpum* is laible to be attacked by the borer *Stromatium barbatum* Fabr. (Fam. Cerambycidae order Coleoptera). Swain states that Australian wood of this genus (sp. gr. approx. 0·87 air-dry) seasons well under cover without shrinkage and splitting, but is not durable. It is used as a substitute for 'boxwood' and is excellent for carving, turnery and inlaying.

Uses—It is suitable for small turnery articles like toys.

Material—

P. eriocarpum – 4839 Mussoorie (0·74).

P. floribundum – 4836 Dehra Dun, 6514 Burma (0·68).

P. tetraspermum – 3778 Ganjam (0·72), 3862 Nilgiris, Madras (0·71).

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K. A. CHOWDHURY AND D. N. BADOLA.

9. POLYGALACEAE

The milkwort family consists of 10–15 genera and about a thousand species of herbs and shrubs and a few trees. Although largest number are found in the warm regions, they are cosmopolitan in distribution, except in New Zeland, Polynesia and the Arctic zone.

Some of the plants have medicinal properties and a few are acrid and poisonous; well known among them is *Polygala senega* L. of America, the roots of which possess tonic, expectorant and emetic properties.

The family is represented in India by 4 genera, 3 of which have woody representatives. The only woody genus not dealt with here is *Securida* L., which is represented by a single species in Assam and Burma.

The climbers belonging to this family are reported to have woods with included phloem. The woods of the two genera studied, have however no such structure, and exhibit distinctly different anatomical structure.

Key to the genera

Pores large to very large, very few to few, exclusively solitary; soft tissues in fine faint wavy tangential lines forming irregular net work with the rays .. *Xanthophyllum*

Pores small to very small, moderately numerous, mostly in short radial multiples; soft tissues in concentric bands delimiting the growth rings .. *Polygala*.

1. POLYGALA L.

A genus of herbs rarely shrubs, widely distributed throughout the world. More than a dozen species have been reported to grow in India, only two of which are woody. The only species available for study is described here.

P. arillata Ham.—redeye, yellow milkwort.—*dieng-ja-kyba*, *dieng-soh-tynka* (Kh.), *michepnor*, *michepnor-kung* (Lep.), *karima*, *marcha* (Nep.). A shrub 1·2–2·4 m. in height, sometimes up to 3·7 m. in Western Ghats. *Bark* yellowish-grey, thin.

It occurs in the Himalayas from Nepal eastwards at 600–2,100 m., Khasi and Jaintia hills, Cachar, Burma (Ava), and Western Ghats.

Description of the wood

[Pl. 9, 51]

General properties—Wood light yellow in colour, moderately hard, heavy (sp. gr. 0·77 air-dry); straight-grained; fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by thin bands of soft tissues, 9–10 per cm. *Pores* small to very small, distinctly visible or just visible under hand lens, moderately numerous (12–19 per mm.^{2}), more or less evenly distributed, mostly in radial multiples of 2–5, which are often arranged in radial chains and occasionally solitary, round ; vessel lines inconspicuous. *Soft tissues* in concentric bands delimiting the growth rings and also in short broken tangential lines indicating somewhat like growth rings. *Rays* fine to very fine, widely spaced and evenly distributed.

Insect attack—The dry wood is liable to be attacked by the borer *Stromatium barbatum* Fabr. (Fam. Cerambycidae order Coleoptera).

Uses—It may be tried for articles like toys.

Material—

4040 Ootacamund (damaged), 5702 S. Coimbatore, Madras (0.77).

2. XANTHOPHYLLUM Roxb.

A genus of trees and shrubs which occur in India, South East Asia and in tropical Australia. In the Indian region about 6 species have been reported to grow, five of which were available for study. The woods of various species of *Xanthophyllum* are indistinguishable.

1. **X. andamanicum** King—A moderate-sized tree. *Bark* grey, smooth ; a very common tree of Andaman islands.

Description of the wood—See page 61.

2. **X. flavescens** Roxb.—*ajensak*, *gandi* (Beng.), *thitpya* (Burm.), *madakka*, *madaku*, *mottal* (Mal.), *palala* (Sinh.), *mattei* (Tam.). A large evergreen tree. *Bark* dark green, smooth 1·3 cm. thick.

It is found in the western part of the Peninsula from Nilgiris southwards, hills of Assam and Chittagong and in Burma.

Description of the wood—See page 61.

3. **X. glaucum** Wall ex Hassk.—*thitpayu* (Burm.). An evergreen tree. *Bark* dark grey with distant, deep, very long horizontal clefts, 1·3 cm. thick.

It occurs in Burma, in moist places often forming strips of pure shady forests.

Description of the wood—See page 61.

4. **X. griffithii** Hook f.—A tree attaining 15 m. in height, which occurs in Burma, Tenasserim and Mergui.

Description of the wood—See page 61.

5. **X. virens** Roxb.—An evergreen tree 15 to 18 m. in height. Brandis considers it to be a form of *X. flavescens* Roxb.

It is found in Chittagong and in the tropical forests of Pegu Yoma.

Description of the wood—See below.

Description of the wood

(*Xanthophyllum andamanicum*, *X. flavescens*, *X. glaucum*, *X. griffithii*, and *X. virens*)

[Pl. 9, 52]

General properties—The colour of the wood varies from pale yellow to various shades of brownish or orange yellow, usually with bluish black patches due to fungus attack ; moderately hard to hard ; moderately heavy to heavy (sp. gr. 0·64–0·89 air-dry) ; straight to slightly twisted-grained ; somewhat coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, demarcated by darker coloured fibrous tissue devoid of parenchyma cells, 4–9 per cm. *Pores* large to very large, distinctly visible to the eye, very few to few (1–5 per mm.^{2}), more or less evenly distributed, exclusively solitary, occasionally with a tendency to arrange in somewhat oblique lines or in irregular groups, round, sometimes filled with yellowish gummy substance ; vessel lines prominent. *Soft tissues* distinct under hand lens, abundant, in fine short interrupted, faint, wavy tangential lines forming almost a network with the rays and also in more or less continuous, wavy tangential lines, rather unevenly distributed. *Rays* extremely fine, just visible under hand lens, closely spaced and evenly distributed.

Strength—It is a hard and strong timber. Bourdillon's experiments with *X. flavescens* in 1896 gave the value of P (The coefficient of transverse strength) = 567 and weight 48 lb. per cft. (sp. gr. approx. 0·77).

Insect attack—Logs of *X. glaucum* are liable to be attacked by pin-hole and shot-hole borers of the order Coleoptera.

As can be judged from the samples examined the timber appears to be easily susceptible to fungus attack. Philippine and Malayan woods of the genus *Xanthophyllum* are reported to possess good strength but are easily perishable, when exposed to the weather or in contact with ground. Reyes states that *X. excelsum* (Blume) Miqued. (sp. gr. 0·73 air-dry) of Philippines dries well with little warping and checking and works easily. But the samples examined by us are all badly cracked.

Uses—It may be suitable for constructional purposes after preservative treatment.

Material—

X. andamanicum – 6728 South Andaman (0·71).

X. flavescens – 4633 Travancore (0·73), 6630 Burma (0·77), 7112 Burma (0·64).

X. glaucum 6094 Tavoy, Burma (0·67), 6128 Tharrawaddy, Burma (0·69), 6372 Burma (0·53).

X. griffithii – 6428 Burma (0·89).

X. virens – 6813 Burma (0·80), 6289 Burma (0·68).

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S. K. PURKAYASTHA.

10. TAMARICACEAE

A small family of 4–5 genera and about 100 species of small trees and shrubs found chiefly in deserts, shores and steppes of the Mediterranean region and Central Asia.

Several species of *Tamarix* are cultivated for the fixation of sand dune, afforestation on sea shores and also for ornamental purposes. The manna of the Beduins, is produced by *Tamarix mannifera* Ehreny., when the twigs are injured by insects. The galls found on members of *Tamarix* are used in dyeing and reported to have medicinal properties. Tannin is sometimes extracted from the galls and the bark. Timber of the family is for the most part locally used.

In India about 8 species belonging to 2 genera, are known to grow. The colour of the wood varies from pale grey to yellowish-grey to reddish-brown. The wood is characterised by broad to very broad, widely spaced rays and by the tendency of the pores to be grouped into clusters or in irregular chains. Soft tissues usually form a sheath round the pores or pore groups which may or may not be visible under hand lens.

Key to the woods

The two genera dealt here cannot be always distinguished with certainty under hand lens. However, there is some slight difference in the general structure of the four species and the information given below may be useful in seperating them into two groups :—

1. Wood typically semi-ring porous, early wood pores small to very small, visible only under hand lens, latewood pores extremely small individually indistinct under hand lens. Soft tissues indistinct or barely visible under hand lens .. *Myricaria germanica.* *Tamarix ericoides.*

2. Wood diffuse porcus, with a very slight semi-ring porous tendency. Pores mostly moderately large, visible to the eye. Soft tissues distinctly visible under hand round the pores or pore groups forming a thin sheath .. .. *Tamarix articulata.* *T. dioica.*

MYRICARIA Desv.

A genus of shrubs which occur throughout the temperate regions of Europe and Asia ; the largest number of species being confined to China. In the Indian region only one species is known to grow.

M. germanica Desv.—*ombu, shalakat* (Lahoul), *bis, humbu, kathi, ombu, shalakat* (Punj.). A gregarious shrub, 30–90 cm. in height and up to 13 cm. in diameter. *Bark* rough, brownish, about 3 mm. thick.

This shrub is commonly found along the rivers in the inner Himalayas from the Punjab to Sikkim a 3,000–4,000 m. and often the only woody vegetation at this height ; also in Tibet, western and northern Asia and on the mountains of Europe.

Description of the wood

[Pl. 9, 53]

General properties—Wood yellowish-white turning light brown on ageing, moderately hard ; heavy (sp. gr. 0·75 air-dry) ; straight to twisted-grained, fine and uneven-textured.

Gross structure—A semi-ring porous wood. *Growth rings* distinct, delimited by somewhat larger early pores, about 4 per cm. *Pores* in the early wood small to very small, visible only under hand lens, moderately numerous, solitary and in radial or oblique pairs or in clusters of 3–5, a tendency for tangential arrangement of the pores or pore groups may often be found, roundish, transition from early to late wood gradual ; late wood pores extremely small, individually indistinct under hand lens ; vessel lines indistinct. *Soft tissues* indistinct or barely visible under the hand lens round the pores or pore groups. *Rays* broad to moderately broad, distinctly visible to the eye, rather widely spaced ; radial flecks present but not very prominent.

The wood is moderately hard and strong, but is liable to be attacked by borers.

Uses—It may be suitable for small articles like toys, small scales, etc.

Material—

974 Chumbi Valley, Tibet (0·75).

TAMARIX L.

A genus of shrubs and small trees distributed in Europe, Asia and Africa. In India about 7 species are known to grow of which 3 were available for study.

1. *T. articulata* Vahl. – **tamarisk**—*asrelei, faras, farwa, kharlei, narlei, ukhan* (Punj.). A moderate-sized tree, sometimes reaching 18 m. in height and 1·9–2·2 m. in girth. *Bark* grey, rough.

It is found throughout the Punjab, Sind, Baluchistan and North-West Frontier Provinces and now extensively cultivated in the irrigated plantations

on saline soils, a feature of old river beds and one of the commonest trees of the country side – also extending westwards to Egypt.

Description of the wood

[Pl. 9, 54]

General properties—Wood pale yellowish or greyish-brown ; moderately hard to hard (sp. gr. 0·60–0·75 air-dry) ; straight-grained ; coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, delimited by lighter coloured fibrous tissue, 1–2 per cm. *Pores* moderately large, few to moderately few (4–8 per mm.^{2}) more or less evenly distributed, occasionally arranging in somewhat concentric rows separated by tracts of fibrous tissue, having very few pores or devoid of pores, solitary or in radial or oblique pairs and also in clusters of 3–5, round ; vessel lines prominent. *Soft tissues* visible under the hand lens, mostly round the pores or pore clusters forming a sheath and occasionally connecting them across the rays. *Rays* broad to very broad, prominent to the eye, widely spaced, evenly distributed ; radial flecks conspicuous. *Ripple marks* present, faintly visible under hand lens.

Strength—It is a moderately hard and strong timber.

Seasoning—It requires careful seasoning ; the logs should be converted when green, the stock open-stacked and protected from direct rays of the sun and from hot wind (Pearson and Brown).

Durability—The timber is not very durable.

Insect attack—Living trees are liable to be attacked by *Cossus acronyctoides* Moore (Fam. Cossidae Order Lepidoptera) and dead or dying trees, by *Aeolesthes holosericea* F. (Fam. Cerambycidae Order Coleoptera). Both these borers attack the timber severely and make it almost useless.

Working qualities—It can be worked to a smooth surface. When quarter sawn it shows a pleasant figure.

Supply and uses—The timber is available in all districts of the Punjab. Mostly used as a cheap fire wood and a wind break. Also in small quantities for turnery (Chowdhury).

Material—

886 Multan (0·75), 5141 Punjab (0·60), 6048 Lahore (0·66).

2. T. dioica Roxb. – **tamarisk**—*lal jhau* (Beng.), *byaung-chedauk* (Burm.), *jhau* (Hind.), *kachlei*, *koan*, *lei*, *pilchi* (Punj.), *gaz*, *jhau*, *lao* (Sind.). A gregarious shrub or a small tree, sometimes up to 7·5 m. in height and 20 cm. in diameter (Osmaston). *Bark* grey, with reticulate cracks, showing the red inner bark.

It is found throughout India, from Sind and the Punjab to Assam, S. India and Burma.

Description of the wood

[Pl. 10, 55]

General properties—Wood reddish-brown ; moderately hard (sp. gr. 0·71–0·72 air-dry) ; straight to twisted-grained, medium-coarse-textured.

Gross structure—A diffuse-porous wood with semi-ring-porous tendency. *Growth rings* distinct, demarcated by larger early pores, 1–4 per cm. *Pores* in the early wood moderately large, and the late wood small to very small, transition from early to late wood gradual, moderately numerous to numerous, rather crowded in the early wood, solitary or in oblique pairs or occasionally in short oblique or irregular rows of 2–3, often in clusters, round ; vessel lines distinct. *Soft tissues* visible only under hand lens, forming a sheath round the pores or pore groups. *Rays* broad to very broad, prominent to the eye, widely spaced and evenly distributed, radial flecks prominent. *Ripple marks* very faint, visible under hand lens.

Uses—Mostly used as fire wood.

Material—

888 Multan (0·72), 1388 Lahore (0·71).

3. T. ericoides Rottl.—tamarisk, *jao, sarab, sarata* (Mar.), *lal jhau* (Hind.), *shushar* (Lahaul). A shrub. *Bark* dark brown vertically cleft.

It is found in the river beds in Bengal, Central and Southern and Western India.

Description of the wood

General properties—Wood yellowish-grey ; moderately hard (sp. gr. 0·60 air-dry) ; straight-grained ; fine-textured.

Gross structure and other properties—Very similar to *Myricaria germanica*.

Material—

4168 Kistna, Andhra (0·60).

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S. K. PURKAYASTHA.

11. HYPERICACEAE

A family of herbs, shrubs and rarely trees. According to Engler it is a tribe of the family *Guttiferae*. It comprises of about 8 genera and 350 species, which occur in the temperate and warm regions. Economically the plants are of little importance. A few species of *Hypericum* L., are cultivated as garden plants, and several species of *Cratoxylon* yield timbers of local utility in South-East Asia.

Of the two genera found in India, one is dealt with here. The other *Hypericum* L., is represented by only herbs and small shrubs.

CRATOXYLON Blume

Moderate-sized trees and shrubs of this genus occur in South-East Asia. Five species are known to grow in the Indian region, only one of which was available for study.

C. neriifolium Kurz—*bebya*, *mahkame* (Burm.). A shrub or a moderate-sized tree up to 12 m. in height with a clear bole of 3·5–6·0 m. and 60–90 cm. in diameter. *Bark* dark brown or blackish, rough, longitudinally and deeply cracked.

It is found in the Chittagong hill tracts and throughout Burma, mostly in the drier hill forests.

Description of the wood

[Pl. **10**, 56]

General properties—Wood greyish-brown ; hard ; heavy (sp. gr. 0·81–0·91 air-dry) ; straight-grained ; fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct, occasional darker bands of fibrous tissue may, however, give the impression of growth rings. *Pores* small to very small, just visible to the eye, moderately numerous to numerous (12–38 per mm.^{2}), uniformly distributed except in slow grown portions, mostly in radial multiples of 2 or 3, occasionally solitary, usually with a tendency for radial alignment, roundish ; vessel lines inconspicuous. *Soft tissues* visible to the naked eye, in thin, wavy, long or short concentric bands. *Rays* fine to very fine, not visible to the eye, closely and evenly spaced. *Pith flecks* occasionally present.

Strength—It is a hard and strong timber.

Insect attack—The sapwood is liable to be attacked by the borer *Mecistocerus fluctiger* Fst. (Fam. Curculionidae, order Coleoptera).

For the Indian species no information on seasoning properties and working qualities is available. However, members of this genus growing in the Philippine Island are said to season well and take good polish. But their durability is short, when in contact with ground.

Uses—It is used for building purposes, agricultural implements and tool handles. It is a favourite wood for firewood and charcoal.

Material—

6252 Burma (0·90), 6296 Burma (0·82).

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K. N. TANDON AND S. K. PURKAYASTHA.

12. GUTTIFERAE

It is a family of about 35 genera and 400 species of trees and shrubs widely distributed in the tropics.

Members of this family yield yellow to greenish-yellow gum-resins, which are used in medicine and also by artists. The gamboge of commerce is the gum-resin obtained from *Garcinia morella* Desv. Several other species of *Garcinia* also yield gamboges which may not, however, be of the same quality as that of *G. morella*. Some members of the family serve as ornamental trees in gardens. Others are cultivated for edible fruits, for example, the mangosteen (*Garcinia mangostana* L.) and the mammee apple (*Mammea americana* L.) are now extensively cultivated in the warmer parts of the world. Edible oils are also obtained from the seeds of *Garcinia* and several other genera.

The family includes many timber trees of commerce. The best known amongst them belong to the genera *Calophyllum* and *Mesua*. *Calophyllum* grows in the tropical regions chiefly in South-East Asia, while *Mesua ferrea* is confined to the Indo-Malayan region.

Six genera occur in the Indian region and all of them have been dealt with here. The colour of the wood, except *Garcinia* (partly), varies from reddish-brown to different shades of red or pink. The wood is mostly hard to very hard and heavy to very heavy with the exception of *Calophyllum* and *Garcinia* (partly). It has usually an interlocked grain. The texture is medium-coarse except in *Kayea* and *Ochrocarpus*. From anatomical point of view the family may be divided into two groups. The first group shows prominent to slight tendency for arrangement of the pores in the radially oblique direction. This phenomenon is very prominent in the genera *Calophyllum* and *Mesua* and not so in *Kayea*, *Ochrocarpus* and *Poeciloneuron*. All of these genera characteristically show solitary pores.

The second group includes *Garcinia* which shows evenly distributed pores which are frequently in pairs.

Key to the Genera

1. Vessels frequently in radial multiples of 2–3 ... *Garcinia*
1. Vessels almost exclusively solitary 2
    2. Soft tissues either indistinct or just visible to the eye, not in tangential lines or bands 3
    2. Soft tissues distinct to the eye, in tangential lines or bands 4

3. Pores small to very small, not visible to the eye; radial canals distinctly visible under the hand lens .. *Ochrocarpus*

3. Pores moderately large, visible to the eye; radial canals not visible, (absent) .. .. .. *Poeciloneuron*

4. Pores small to very small, indistinct to the eye, moderately numerous to numerous, showing only a slight tendency for oblique alignment .. *Kayea*

4. Pores moderately large, visible to the eye, few to moderately few, showing characteristically oblique arrangement 5

5. Wood very hard and very heavy .. .. *Mesua*

5. Wood moderately hard and moderately heavy .. *Calophyllum*

1. CALOPHYLLUM L.

A large genus of trees which occur in the tropics, chiefly in India and South-East Asia. Of nearly a dozen species indigenous in the Indian region, 8 have been dealt with here. The woods are indistinguishable.

1. **C. amoenum** Wall.—poon. A moderate-sized, straight-stemmed tree, 12–18 m. in height and 1·2–2·1 m. in girth. *Bark* yellowish, smooth.

It occurs in the Andamans and in Tenasserim.

Description of the wood—See page 71.

2. **C. inophyllum** L.—poon. *kath champa, sultan champa* (Beng. and Hind.), *hpang, paungnyit, ponnyet* (Burm.), *udi* (Cutch), *hona, surahonne, vuma* (Kan.), *pinna, punna* (Mal.), *surangi, undi* (Mar.), *poonang, punnag* (Or.), *pinnai, punnai* (Tam.), *ponna, punna* (Tel.). A moderate-sized tree in most localities, but attaining 15–18 m. in height and 2–4·5 m. in girth in Tenasserim. *Bark* blackish-brown.

It is "found along the coast above high water mark and in the mangrove forests of Burma, down the West Coast from Konkon southwards, along the Orissa Coast, common in Tenasserim and in the Andamans" (Pearson and Brown); also cultivated for ornamental purposes.

Description of the wood—See page 71.

3. **C. kunstleri** King—poon. *tharapi* (Burm.). A tall tree found in Tavoy, Burma.

Description of the wood—See page 71.

4. **C. polyanthum** Wall. (**C. polyanthum** Wall. ex Planchon and Triana)—poon. *kandeb* (Beng.), *telo* (Cach.), *dieng-la-karu* (Kh.), *sentebel* (Kuki), *paiyunkung* (Lep.), *rate* (Nep.). A medium-sized to large tree

9–18 m. in height with a clear bole of 4·5–9 m. and 1·2–3 m. in girth. *Bark* grey or brown, rough, exfoliating in oblong flakes, about 8 mm. thick.

It is found in the hill forests of North Bengal up to 1,500 m. elevation, and in the hills of Assam, Burma and Chittagong.

Description of the wood—See below.

5. C. spectabile Willd. (C. sculattri Burm. f.)—poon. The Nicobar canoe tree. *pantaga, tharapi* (Burm.), *lalchini* (Hind.). A large tree 18–24 m. in height and 1·2–2·1 m. in girth. *Bark* yellowish, usually with fine longitudinal fissures.

It occurs in Tenasserim and in the Andamans, from the coast upwards, in damp evergreen forests (Pearson and Brown).

Description of the wood—See below.

6. C. tomentosum Wight (C. elatum Bedd.)—poon. *salhone, shri honay, surhoni* (Kan.), *katta pinna, malampunna, pinnapai, punna* (Mal.), *nagari* (Mar.), *kattu-pinnai, pinnai, srihonnai* (Tam.), *viri* (Travan. hills). A very large cylindrical-stemmed tree, attaining up to 46 m. in height with a clear bole of more than 24 m. and 4·5 m. in girth. *Bark* yellowish, with very long wavy vertical fissures.

It occurs in the evergreen forests of Western Ghats, from North Kanara to Travancore ascending up to 1,500 m. elevation.

Description of the wood—See below.

7. C. venustum King—poon. A small tree about 9 m. in height, found in the hill forests of Burma at 1,500 m. elevation.

Description of the wood—See below.

8. C. wightianum Wall. (C. apetalum Willd.)—poon. *irai* (Kan.), *attupunna, cherupunna, manjapunna* (Mal.), *bobbi* (Mar.), *cherupinnei, sirapunna, valuluvai* (Tam.). A moderate-sized to large tree up to 21 m. in height and 60 cm. in diameter. *Bark* yellowish-brown, deeply cracked, thick.

It is found in the Western Ghats from North Kanara to Travancore, on the banks of rivers and in the evergreen forests.

Description of the wood—See below.

Description of the wood

(*Calophyllum amoenum, C. inophyllum, C. kunstleri, C. polyanthum, C. spectabile, C. tomentosum, C. venustum* and *C. wightianum*)

[Pl. 10, 57–60 ; Pl. 11, 61–63]

General properties—Sapwood and heartwood fairly sharply demarcated in the freshly felled timber, but usually less so on ageing ; sapwood pale reddish-white to yellow, heartwood yellowish to reddish-brown with darker streaks on

the longitudinal surface, turning dull greyish, with smooth feel, moderately hard; mostly moderately heavy (sp. gr. 0·47–0·84 air-dry); lustrous; twisted-grained; medium-coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* absent. *Vessels* large to moderately large, outlines just visible to indistinct to the eye, few to moderately few (2–7 per mm.^{2}), arranged in oblique lines or festoons, almost exclusively solitary, round, occasionally plugged with tyloses or filled with gummy deposits; vessel lines conspicuous. *Soft tissues*, (*a*) reddish, distinctly visible to the eye, apotracheal, in fairly thick, slightly wavy, tangential lines ending abruptly, and as a rule widely and irregularly spaced, (*b*) vasicentric tracheids distinctly visible under the hand lens forming thin sheaths resembling somewhat the soft tissues. *Rays* fine to very fine not visible to the naked eye, closely spaced, evenly distributed.

Strength—Four species have been tested for strength at Dehra Dun, viz., *C. inophyllum*, *C. polyanthum*, *C. tomentosum* and *C. wightianum*. For strength figures see appendix I.

Tests carried out by Prof. Everett on *C. spectabile* gave the following results:—

Transverse strength in lb. per sq. in.		Crushing strength parallel to the grain, in lb. per sq. in.
Breaking strength	Modulus of elasticity or Young's modulus	
15,800	2,067,000	9,140

Seasoning—The timber is easy to season, though somewhat liable to short surface cracks, which can be avoided if stacked with crossers under cover. *C. wightianum* is considered to be a little more liable to splitting and surface cracking than the others. It should not, however, offer any difficulty provided sufficient care is taken in stacking.

Natural durability—Only two species, viz., *C. tomentosum* and *C. wightianum* have been tested in the graveyard at Dehra Dun. The former lasted for 41 to 81 months and the latter 38 to 81 months.

Insect attack—The sapwood of the newly felled logs of *C. spectabile* is liable to be attacked by the shot-hole borer *Crossotarsus saundersi* Chap. (Fam. Platypodidae, order Coleoptera). Other species, e.g., *C. wightianum*, are also known to be damaged by insects in the log form and debarking the logs soon after felling is, therefore, recommended.

Preservative treatment—The two species tested at Dehra Dun, viz., *C. tomentosum* and *C. wightianum* showed that both are refractory to wood preservatives.

Working qualities—Straight-grained timber is easy to saw and works to a smooth surface and shows a pleasant figure. But being mostly twisted or interlocked-grained, the timber is rather hard on the tools and is, therefore, not recommended for the manufacture of rotary cut veneers and plywood. It is, however, quite suitable for conversion into veneer sheets by the sawing method. Once finished, it takes a good polish.

Supply and uses—Poon is available in fair quantities from the south zone and limited supplies are also available from the west zone and the Andamans. It is usually available in good lengths ; logs up to 22 m. long and squaring to over 60 cm. of *C. tomentosum* are sometimes available. The timber is mostly used for constructional purposes, e.g., bridges, poles, ceiling boards, planking and rafters. It is also used for the manufacture of furniture, particularly from the figured stock, heavy packing boxes, tent poles, and veneers and plywood. Poon is a well known material for boat and ship building, logs of long lengths being usually utilized as masts and spars. But as mentioned by Trotter the recorded figures of strength "do not give a true picture of excellence of this timber for masts and spars".

Material—

C. amoenum – 6149 Tavoy, Burma (0·64), 6360 Burma (0·62).

C. inophyllum – 733 S. Kanara (0·56), 2257 Andamans (0·68), 2258 Andamans (0·68), 5228 Andamans (0·60), 5229 Andamans (0·62), 5230 Andamans (0·65), 5912 N. Mangalore (0·63), 5925 S. Kanara (0·84), 6804 Burma (0·58), 7814 S. Kanara (0·66), 7860 S. Kanara (0·67), 7861 S. Kanara (0·63).

C. kunstleri – 6735 Burma (0·67).

C. polyanthum – 1400 Chittagong hill tracts (0·68), 6011 Chittagong hill tracts (0·56), 7786 Darjeeling (0·77).

C. spectabile – 525 Andamans (0·65), 6032 Mergui, Burma (0·65).

C. tomentosum – 1279 Coimbatore (0·57), 5351 Coimbatore (0·54), 5913 N. Mangalore (0·57), 5931 S. Kanara (0·63), 5955 Palghat (0·49), 5981 Coorg (0·71), 7816 S. Kanara (0·47).

C. venustum – 7157 Burma (0·67).

C. wightianum – 861 S. Kanara (0·67), 5914 N. Mangalore (0·71), 7815 S. Kanara (0·71).

2. GARCINIA L.

A very large genus of trees, rarely shrubs, occurring in the tropics of the old world. Of about 30 species growing in India, 12 were available for study.

The woods of these show considerable variation both in anatomical structure and in physical properties. The woods of *G. echinocarpa* and *G. speciosa* are dark reddish-brown in colour, while the remaining species are greyish or brownish-yellow. Based on anatomical structure the species, other than the two mentioned above can be roughly divided in to following three groups :—

Group I.—Parenchyma vasicentric to aliform to confluent. Pores moderately numerous to numerous ...	*G. morella* *G. travancorica* *G. wightii*
Group II.—Parenchyma aliform confluent to fine broken tangential lines. Pores moderately numerous ...	*G. heterandra* *G. imberti*
Group III—Parenchyma in fairly broad lines and bands. Pores moderately few	*G. cambogia* *G. cowa* *G. indica* *G. spicata* *G. xanthochymus*

1. **G. cambogia** Desr.—*manthulli* (Coorg), *dharambe, mandahuli, oopagimara, punarahuli* (Kan.), *kodapuli, mampulichi, penenga, pineru* (Mal.), *kodukapuli, penampuli* (Tam.). A middle-sized tree. *Bark* grey, smooth, containing abundance of bright yellow gamboge, thin.

It is found in the evergreen forests in the Western Ghats from Konkan to Travancore ascending up to 1,800 m. in the Nilgiris.

Description of the wood—See page 76.

2. **G. cowa** Roxb.—*chop-chopa, kaugach, kau-thekera, kuji-thekera* (Asm.), *kau, kowa* (Beng.), *taung-thala, yekabyin* (Burm.), *hau* (Cach.), *blachung-change* (Duff.), *denga-doti, rengran, tekra* (Garo), *kataphal* (Hind.), *dieng-soh-longksan* (Kh.), *Khatoksi* (Mechi), *tarak-asing* (Miri and Abor), *kaphal* (Nep.), *sarabana* (Or.), *kau* (Sylh., Cach., Manip. and Naga). A medium-sized to large tree 12–21 m. in height and 90 cm.–1·5 m. in girth. *Bark* dark brown or blackish, slightly rough, thin.

It is found in Assam ascending to 900 m., Chittagong, Andamans and Burma, and rarely found in North Bengal, Bihar and Orissa. According to Brandis it also occurs in the Nilgiris and elsewhere in the Peninsula. It is cultivated for fruit.

Description of the wood—See page 76.

3. **G. echinocarpa** Thw.—*pura* (Mal.) *kambilipisini*, *madul*, *malaipunna*, *malankongu* (Tam.). A tree attaining 15 m. in height. *Bark* smooth, thin.

It occurs in the moist forests of South Travancore and Tinnevelley at 900 to 1,500 m. elevation.

Description of the wood—See page 76.

4. **G. heterandra** Wall.—*tawmingok* (Burm.). A tree occurring in Mergui, Burma.

Description of the wood—See page 76.

5. **G. imbertii** Bourdillon—*manja-kanji* (Tam.). A medium-sized tree, found in South Travancore above 1,100 m.

Description of the wood—See page 76.

6. **G. indica** Choisy—*brindall* (Goa), *kokum* (Hind.), *murgal*, *murinahuli* (Kan.), *kodampuli*, *penampuli* (Mal.), *bhirand*, *ratamba* (Mar.). A tall slender tree. *Bark* light brown, shiny, smooth, thin.

It is apparently endemic in the Western Ghat moist tropical rain-forests; common in many of the North Kanara and South Konkan evergreens (Talbot); often planted for fruits.

Description of the wood—See page 76.

7. **G. morella** Desr.—The gamboge tree. *kuji-thekera* (Asm.), *gota gamba* (Hind.), *ardala*, *arsina gurgi*, *hardala*, *kankutake*, *punarpuli* (Kan.), *korbomba* (Kuki), *chigiri* (Mal.), *sundar-kau* (Sylh.), *makki* (Tam.). A medium-sized tree up to 12 m. in height. *Bark* dark reddish-brown, smooth, exfoliating, 8 mm., thick.

It occurs in the Western Ghats from South Kanara and Mysore to Travancore, and in Assam and Sylhet.

Description of the wood—See page 76.

8. **G. speciosa** Wall.—*palawa*, *parawa*, *pa-wa* (Burm.). A tree 9–15 m. in height and 90 cm.–1·5 m. in diameter. *Bark* greyish-black, thin.

It occurs in Andaman islands and in Tenasserim.

Description of the wood—See page 76.

9. **G. spicata** Hk. f.—*manja nangu* (Mal.), *haldi* (Mar.), *kokottai* (Tam.), *pidatha* (Tel.). A moderate-sized to tall tree up to 21 m. in height with a straight trunk. *Bark* grey, rough, thick.

It occurs in the Western Ghats from Konkan southwards and in the east coast in Andhra and Karnatak – also in Ceylon.

Description of the wood—See page 76

10. **G. travancorica** Bedd.—*malampongu* (Mal.). A medium-sized tree up to 15 m. in height and 30 cm. in diameter. *Bark* brown, rough, thin.

It is found in the evergreen forests of South Travancore and Tinnevelly above 1,100 m. elevation.

Description of the wood—See below.

11. **G. wightii** T. Anders.—*attukaruka, pulimaranga* (Mal.). A small tree. *Bark* brown, rough, thin.

It occurs in Travancore on river banks up to 600 m. elevation.

Description of the wood—See below.

12. **G. xanthochymus** Hk. f.—*tepol-tenga, tepor* (Asm.), *dampel* (Beng.), *hmandaw, hmetlein, madaw* (Burm.), *aruak* (Garo), *davangi, deavkai, devagarige, devanhuli, gansargi, garigehuli, janagi, javangi* (Kan.), *dieng-soh-khyllung, dieng-soh-rynsan* (Kh.), *dharambe* (Konkan), *taksal-kung* (Lep.), *anavaya* (Mal.), *jharambi* (Mar.), *thesampreng* (Mik.), *chunyeb* (Nep.), *cheoro, chiuri, sitambu* (Or.), *dephal* (Sylh.), *makki* (Tam.), *iwara mamadi* (Tel.), *demphal, taoikoy* (Tipp.). A small to medium-sized tree 9 to 15 m. in height and 90 cm.–1·5 m. in girth. *Bark* brown, thin, exfoliating in small flakes.

It grows in North Bengal up to 1,500 m. elevation, evergreen forests of Assam, Chittagong, Burma, Andamans, Orissa, Andhra, Western Ghats from North Kanara southwards, also cultivated.

Description of the wood—See below.

Description of the wood

(*Garcinia cambogia, G. cowa, G. echinocarpa, G. heterandra, G. imberti, G. indica, G. morella, G. speciosa, G. spicata, G. travancorica, G. wightii* and *G. xanthochymus*)

[Pl. **11**, 64–66; Pl. **12**, 67–69]

General properties—Wood greyish to brownish-yellow turning pale brown on ageing, but dark reddish-brown in *G. echinocarpa* and *G. speciosa*; mostly hard to very hard but a few samples moderately hard; moderately heavy to heavy (sp. gr. 0·61–0·95 air-dry); straight to twisted-grained; medium to fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct but occasional bands of dark coloured fibrous tissue or fairly continuous bands of soft tissue may, however, give the impression of growth rings. *Pores* very small to moderately large; (*a*) moderately large and visible to the eye in *G. cambogia, G. cowa, G. indica* and *G. xanthochymus* (partly), (*b*) small, not visible or just visible to the eye in *G. spicata* and *G. xanthochymus* (partly), (*c*) small to very

small and not visible to the eye in the remaining species ; the frequency of the pores varies from few to numerous (3–30 per mm.^{2}), and the species examined can be roughly be divided into 5 overlapping classes, (*a*) few to moderately few in *G. cambogia*, *G. cowa*, *G. indica* and *G. xanthochymus*, (*b*) moderately few to moderately numerous in *G. spicata*, (*c*) moderately numerous in *G. echinocarpa*, *G. imberti*, *G. speciosa*, *G. heterandra* and *G. morella*, (*d*) moderately numerous to numerous in *G. travancorica* and (*e*) numerous in *G. wightii*. *Pores* evenly distributed, solitary in radial multiples of 2–3, occasionally up to 5, roundish ; vessel lines inconspicuous to indistinct. *Parenchyma* distinct to indistinct to the eye, vasicentric to aliform to fairly broad tangential lines and bands ; the species examined can be roughly grouped into 3 overlapping classes, (*a*) *Parenchyma* vasicentric to aliform to aliform confluent, in *G. echinocarpa*, *G. morella*, *G. speciosa*, *G. travancorica* and *G. wightii*, (*b*) aliform confluent to fine broken tangential lines in *G. heterandra* and *G. imberti*, (*c*) predominently in fairly broad lines and bands in the rest of the species. *Rays* moderately broad to fine, rather widely spaced to fairly closely spaced, and evenly distributed. *Radial canals* occasionally visible on the tangential surface under hand lens in *G. cowa*.

Strength—A very hard and strong timber. Only three species have been tested, viz., *G. indica*, *G. speciosa* and *G. xanthochymus*. For strength figures see appendix 1.

Seasoning—It is liable to crack and split. Almost all the samples examined were badly cracked.

Natural durability—None of the Indian species have been subjected to graveyard test. Schneider states that the Philippine species are fairly durable, especially the red varieties which have an excellent reputation for posts. Of the 3 Philippine species described by Reyes, one has been stated to be very durable but the other two durable only under cover and not in contact with the ground. From experience it appears that a few of the Indian species may be fairly durable, e.g., *G. spicata*.

Insect and fungus attack—Drywood of *G. indica* and *G. wightii* are liable to be attacked by the borer *Stromatium barbatum* Fabr. (Fam. Cerambycidae, order Coleoptera). Most of the samples examined were attacked by borers and also discoloured by fungus attack.

Uses—*G. speciosa* is reported to be used for bridge posts and constructional purposes. Other species apparently are not very much used at present. It should prove to be a good constructional timber provided the timber is properly treated.

Material—

G. cambogia – 4625 Travancore (0·76), 7864 E. Kanara (damaged).

G. cowa – 549 Martaban, Burma (0·61), 6290 Burma (0·63), 6308 Burma (0·66), 6739 Burma (0·72), 7818 Buxa, Bengal (0·71).

G. echinocarpa – 4692 Travancore (0·87).

G. heterandra – 6821 Burma (0·75).

G. imberti – 4691 Travancore (0·84).

G. indica – 5600 Bombay (0·62), 7817 E. Kanara (0·68), 7819 S. Kanara (0·69), 7820 S. Kanara (0·71).

G. morella – 7863 E. Kanara (0·68).

G. speciosa – 6442 Burma (0·86).

G. spicata – 4727 Travancore (0·93), 7787 Nellore, Madras (0·81), 7788 Nellore, Madras (0·86).

G. travancorica – 4693 Travancore (0·88).

G. wightii – 4724 Travancore (0·83).

G. xanthochymus – 3826 Ganjam (0·87), 7163 Burma (0·95), 7859 S. Kanara (0·87), 7960 N. Kanara (0·96).

3. KAYEA Wall.

A tropical genus of small to medium-sized trees found in South and South-East Asia. Five species have been reported to grow in India and Burma, of which 3 were available for study. The remaining two are – *K. floribunda* Wall., a large tree of Sikkim, Assam and Burma, and *K. manii* King, a rather rare tree of the Andamans. The woods of the 3 species studied are indistinguishable.

1. **K. assamica** King and Prain—*sia-nahor* (Asm.). A tall tree up to 23 m. in height with a clear cylindrical bole of more than 12 m. and 1·8–2·5 m. in girth. *Bark* light browinsh-grey often exfoliating in large square plates.

It is "found gregarious in North Assam, in the Lakhimpur Division, forming a nearly pure crop over 40 sq. miles in the sub-montane forests on the north bank of the Brahmaputra" (Pearson and Brown).

Description of the wood—See page 79.

2. **K. kunstleri** King—*serendab* (Burma). A tree up to 15 m. in height found in Burma.

Description of the wood—See page 79.

3. **K. nervosa** T. And.—*taung-gangaw* (Burm.). A tree 9–12 m. high, found in Mergui, Burma.

Description of the wood—See page 79.

Description of the wood

(*Kayea assamica, K. kunstleri* and *K. nervosa*)

[Pl. 12, 70–71]

General properties—Sapwood grey or pale greyish-brown, fairly sharply demarcated from the dull reddish-brown heartwood, with darker streaks on the longitudinal surface which is usually more prominent in the sapwood ; hard ; heavy (sp. gr. 0·75–0·93 air-dry) ; mostly twisted or interlocked-grained ; medium to fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct, more or less continous and fairly straight bands of soft tissues and sometimes darker bands of fibrous tissues may, however, give the impression of growth rings. *Pores* small, not visible or just visible to the eye, moderately numerous (10–16 per mm.^{2}), but very small and numerous to very numerous in *K. nervosa*, fairly evenly distributed with a tendency to be aligned in oblique lines, almost all solitary, roundish ; vessel lines indistinct. *Parenchyma*, (*a*) abundant, distinctly visible to the eye in more or less continuous, broad (*K. assamica*) to moderately broad, widely spaced, wavy to straight apotracheal bands which end abruptly, and (*b*) vasicentric tracheids which under the hand lens appear like soft tissues, occasionally visible forming thin sheaths. *Rays* fine to very fine, not visible to the eye, fairly closely spaced to closely spaced, evenly distributed.

Of the three species studied, information on physical and mechanical properties and supply, is available for only *K. assamica*, which is given here. *K. floribunda* for which no sample was available for this study has also been tested for strength and natural durability at Dehra Dun. The timber is hard, heavy, strong and elastic, but not durable. Graveyard tests showed that it lasts for about 25 months. It is suitable for tool handles.

Strength—See appendix I.

Seasoning—It is liable to develop surface cracks during seasoning. It should be converted green and protected from sun and hot winds during seasoning.

Natural durability—Not durable to fairly durable, lasts for 18–91 months, average about 67 months.

Preservative treatment—Heartwood very refractory to treatment, side and end penetration is practically nil.

Working qualities—Although it planes to a smooth surface, it is rather difficult to work.

Supply and uses—Fair quantities are available from Assam. It is suitable for tool handles, cabinet work, and also for constructional purposes such as beams and rafters and for internal finish.

Material—

K. assamica – 5776 Lakhimpur, Assam (0·78), 6023 Lakhimpur, Assam (0·93), 7238 Lakhimpur, Assam (0·91), 7374 Lakhimpur, Assam (0·85), 7516 Lakhimpur, Assam (0·90).

K. kunstleri – 6450 Burma (0·87).

K. nervosa – 6171 Mergui, Burma (0·75), 6258 Mergui, Burma (0·77).

4. MESUA L.

A genus of trees widely distributed in India and South-East Asia. The only species found in India is dealt with here.

M. ferrea L.—mesua. *inji* or *ingi-asing* (Abor), *nahor* (Asm., Beng. and Miri), *nagesar, nageswar, nagkesar* (Beng.), *gamgaw, kawtanok, mai-kam-kaw, mai-ting* (Burm.), *atha* (Coorg), *karai, khimdi* (Garo), *khung-khari-baphang* (Kach.), *nagasampige* (Kan.), *dieng-ngai* (Kh.), *kherser* (Kuki), *herse* (Lush.), *churuli, nangu, peri, veluthapala, wayanavu* (Mal.), *uthau* (Manip.), *nagchampa* (Mar.), *nasser-bippang* (Mechi), *micharne* or *phik charnearong* (Mik.), *ngai-ching* (Naga), *nagesuri* (Nep.), *nageshwaro* (Or.), *manga, na, naka* (Sinh.), *nangil, nangu, nangul* (Tam.), *nagakesari* (Tel.), *kharshei* (Tipp.). A middle-sized to large tree up to 24 m. in height and 240 cm. in girth. *Bark* dark brown, peeling off in thin flakes.

It is found in Western Duars, Assam, Chittagong, upper Burma, Tenasserim, Andaman islands, western coast from North Kanara southwards. Generally in evergreen forests (Brandis). It is also reported to be uncommonly met with in Purnea, Mayurbhanj and Orissa. Commonly cultivated.

Description of the wood

[Pl. **12**, 72 ; Pl. **13**, 73]

General properties—Sapwood greyish or pinkish-white fairly sharply demarcated from the brick-red heartwood, occasionally with darker streaks on the longitudinal surface, very hard ; very heavy (sp. gr. 0·93–1·24 air-dry) ; somewhat lustrous ; straight to interlocked-grained ; medium-textured, with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* absent. *Pores* moderately large, outlines of the pores usually not distinct to the naked eye, few to moderately few (2–7 per mm.^{2}), irregularly spaced, almost all solitary, occasionally due to the close proximity appear to be in chains, or clusters, mostly in oblique radial lines or in irregular groups, round, usually plugged with tyloses ; vessel lines conspicuous. *Soft tissues* (*a*) reddish, visible to the eye, apotracheal, in slightly wavy broken tangential lines ending abruptly, widely

spaced, irregularly distributed, (*b*) vasicentric tracheids, forming thin sheaths, somewhat resembling soft tissues, distinctly visible under hand lens. *Rays* fine to very fine, not visible to the eye, closely spaced, evenly distributed.

Strength—One of the hardest and strongest of the Indian timbers. For strength figures see appendix I.

Seasoning—A slow and difficult timber to season. It is prone to surface cracking, warping and splitting if not carefully handled. It should be dried out slowly under cover, protected from hot winds and sun.

Natural durability—One of the most durable timbers ; Graveyard tests, at Dehra Dun of the sample from Assam showed that the timber lasts for 245–287 months but the timber from Madras had a life of 45–227 months only.

Insect and fungus attack—It has the reputation of not being easily attacked by white ants. But the timber sometimes becomes useless because of the tunnels made by the larva of *Chrysochroa* sp. (Fam. Buprestidae, order Coleoptera). Probably the attack develops in the standing tree.

Although several wood-rotting fungi are known to attack the timber, it is not easily susceptible to decay.

Preservative treatment—Heartwood is very refractory to treatment, side and end penetration is practically nil.

Working qualities—Being extremely hard, it is a very difficult timber to saw even when green, and almost impossible to saw if seasoned. It is rather difficult to bring it to a good surface as it is liable to tear up in rough streaks on machines.

Supply and uses—Large supplies are from the east zone, particularly from Assam and also from the south zone. The timber is mostly used for railway sleepers, for constructional purposes, such as house posts and beams and for bridges. It has been used for props in mines, electric transmission poles, wooden shingles, road paving blocks, etc. The timber is also sometimes used in the manufacture of agricultural implements, cart-building and for boat building.

Material—

520 Andamans (1·21), 554 Martaban, Burma (1·16), 741 S. Kanara (1·00), 793 Kamrup, Assam (0·98), 1273 Cachar, Assam (1·10), 2190 Nowgong, Assam (1·08), 2309 E. Duars, Bengal (1·04), 2504 Burma (1·02), 2700 Tavoy, Burma (0·93), 5240 Andamans (1·19), 5241 Andamans (1·24), 5417 Malabar (1·15), 5755 Sibsagar, Assam (0·98), 6018 S. India (1·00), 6425 Burma (0·97), 7223 Chittagong hill tracts (0·93), 7246 Lakhimpur, Assam (0·96), 7292 Cachar, Assam (1·07), 7480 Wynaad, Madras (1·17), 7481 Wynaad, Madras (1·12), 7510 Sibsagar, Assam (1·08),

7642 Nowgong, Assam (1·09), 7784 Kalimpong, Bengal (1·03), 7785 Kalimpong, Bengal (1·03), 7862 E. Kanara (1·00), 7865 S. Coimbatore, Madras (1·05), 7866 S. Coimbatore, Madras (1·05).

5. OCHROCARPUS THOUARS

A paleotropic genus of trees and shrubs. Two species have been reported to grow in the Indian region. The woods of these are indistinguishable.

1. **O. longifolius** Benth. and Hk. f. (**Mammea longifolia** Pl. and Tr.)—*gardundy* (Bombay), *phatapale, punay, surangi, surungi, wundy* (Kan.), *chhuriana* (Or.), *sura-ponna* (Tel.). A moderate-sized to large tree 12 to 18 m. high and 1·8 m. in girth. *Bark* reddish-brown 6 mm. thick, exuding a red gum.

It is indigenous on the Konkan and Kanara Ghats ascending to 600 m. elevation in evergreen forests (Talbot). Cultivated in Orissa and Andhra.

Description of the wood—See below.

2. **O. siamensis** T. And. (**Mammea siamensis** T. And.)—*talapi* (Burm.). A tree. *Bark* brown with prominent lenticels 6 mm. thick.

It is found in Lushai hills of Assam and in Burma.

Description of the wood—See below.

Description of the wood

(*Ochrocarpus longifolius* and *O. siamensis*)

[Pl. 13, 74]

General properties—Sapwood pale brown gradually merging into dull reddish-brown heartwood, occasionally with black dots on the longitudinal surfaces; moderately hard to hard; heavy to very heavy (sp. gr. 0·79–1·07 air-dry); straight to twisted-grained; fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct delimited by dark coloured fibrous tissue, 2–5 per cm. *Pores* small to very small, not visible or just visible to the eye, moderately few to moderately numerous (7–12 per m.^{2}), more or less evenly distributed but with a tendency to be aligned in oblique lines, almost all solitary, round, open or plugged with tyloses; vessel lines inconspicuous. *Soft tissues* just visible or not visible under hand lens, (*a*) diffuse to aggregate and (*b*) paratracheal scanty to vasicentric mixed with tracheids. *Rays* of two types moderately broad and fine to very fine, not always visible to the eye; the former (those with radial gum canals) rather unevenly distributed, and the latter closely spaced and evenly distributed. *Radial gum canals* visible, on the tangential surface as black dots to the naked eye and clearly visible under the hand lens.

Strength—*O. longifolius* has been tested for strength. For strength figures see appendix I.

No information is available regarding seasoning, natural durability, etc., of this timber. But from the examination of the samples available, it appears to be liable to crack. One sample (sapwood) was badly damaged by borer attack. It finishes to a smooth surface and probably not a difficult timber to work. *Mammea americana* L. of America is reported to be moderately resistant to decay.

Uses—Though locally used at present, it appears to have greater possibilities. The timber is suitable for furniture, carpentry, joinery, indoor decoration, planking and for constructional purposes, e.g., beams, rafters.

Material—

O. longifolius – 5324 Khurda, Orissa (0·82), 7959 N. Kanara (1·07).

O. siamensis – 4849 Pyinmana, Burma (0·79).

6. POECILONEURON Bedd.

The genus *Poeciloneuron* consists of two species confined to South India. Wood of only one species was available for study and is dealt with here.

P. indicum Bedd.—**ballagi**, *kirballi* (Kan.), *pulivayala*, *vayila* (Mal.), *puthangali*, *puthangkolli*, *vazhala* (Tam.). A large tree up to 27 m. in height and 75 cm. in diameter. *Bark* grey, rough, 13 mm. thick.

It occurs in evergreen forests of Western Ghats from South Kanara to Travancore ascending to 900 m. elevation.

Description of the wood

[Pl. 13, 75–76]

General properties—Sapwood dull brown, somewhat well demarcated from the darker red-brown heartwood ; hard to very hard ; heavy to very heavy (sp. gr. 0·81–1·09 air-dry) ; straight to interlocked-grained ; medium-coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually absent, darker bands of fibrous tissue may sometimes give the impression of growth rings. *Pores* moderately large to small, usually visible to the eye, moderately few to moderately numerous (7–17 per mm.^{2}), more or less evenly distributed, but with a tendency to be aligned in oblique lines, almost exclusively solitary, but occasionally due to the very close proximity the vessels may appear to be in pairs, round, open or plugged with tyloses ; vessel lines conspicuous. *Soft tissues* (including tracheids) not clearly visible to the naked eye, paratracheal,

mostly aliform to aliform confluent. *Rays* fine to very fine, not visible to the eye, fairly closely spaced to closely spaced, evenly distributed. *Pith flecks* occasionally present.

Strength—A strong, hard and elastic timber. For strength figures see appendix I.

Seasoning—It is a difficult timber to season. It develops deep surface cracks and end-splits, especially during kiln seasoning.

Natural durability—A fairly durable timber; graveyard tests at Dehra Dun showed that it lasts for 51–95 months.

Preservative treatment—Heartwood very refractory to treatment, penetration of preservatives being practically nil.

Working qualities—A hard timber, but works fairly well both by hand and on machines.

Supply and uses—Large supplies are available from the south zone. It is mostly used for constructional purposes, railway sleepers, electric transmission poles and rice pounders.

Material—

4733 Travancore (0·97), 6730 Palghat (1·09), 7772 S. Coimbatore, Madras (0·81), 7773 S. Coimbatore, Madras (0·89), 7774 S. Coimbatore, Madras (0·83), 7775 S. Coimbatore, Madras (1·06), 7867 S. Coimbatore, Madras (0·85), 7868 S. Coimbatore, Madras (0·89).

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K. N. TANDON AND S. K. PURKAYASTHA.

13. THEACEAE

It is a family of trees and shrubs distributed mainly in the tropics and sub-tropics of both hemispheres. There are also a few in China, Japan and the United States of America. According to Melchior, the family contains 23 genera and about 380 species.

The most important member is the tea plant *Camellia sinensis* (Linn.) O. Kuntze. Several other species of *Camellia* are also cultivated as garden plants.

From the point of view of timber, the family is not of much significance. However, *Laplacea brenesii* Standl. of Costa Rica produces structural timber. So do some *Schima* and *Gordonia* of the Indo-Malayan region.

In the Indian region about 25 species belonging to 9 genera have been reported to grow. Of these 7 genera are dealt with here. *Adinandra* Jack and *Cleyera* DC., were not available to us for study.

Colour of wood varies from greyish to different shades of brown and red. In anatomical structure, the family is a homogeneous one. The wood is diffuse to semi-ring porous with small to very small, mostly solitary and somewhat angular pores. Growth rings may or may not be distinct. Soft tissues are usually indistinct or occasionally appear as specks under hand lens. Rays are fine to broad.

Key to the genera

1. Rays prominent to the eye ... ... *Anneslea* (*A. fragrans*)
Eurya
Ternstroemia

1. Rays inconspicuous 2

   2. Pores moderately large to small, just visible to the eye ; wood diffuse-porous, reddish-brown ... *Schima* (*S. wallichii*)
Gordonia (*G. obtusa*)

   2. Pores small to very small, not visible to the eye ; wood semi-ring porous, greyish to pinkish ... *Camellia*
Pyrenaria.

1. ANNESLEA Wall.

The genus is mostly confined to Burma and Malaya. According to Kurz, two species grow in the Indian region, viz., *A. fragrans* Wall. and *A. monticola* Kurz, but Brandis is of the opinion that both are identical.

A. fragrans Wall.—*gangawdwe, ma-mu-pi, meik-tun, ngad-hjyang, panma, taung-gangaw* (Burm.). A medium-sized evergreen tree 7·5–9·0 m. in height, with a clear bole of 3–4·5 m. and 45–60 cm. in girth. *Bark* grey.

It is found in the eng forests of Burma, up to 600 m. elevation and also in southern China and Thailand.

Description of the wood

[Pl. 13, 77]

General properties—Wood light brown ; moderately hard ; moderately heavy (sp. gr. 0·64–0·72 air-dry) ; straight-grained ; usually medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct, occasionally dark bands of fibrous tissue may, however, give an impression of growth marks. *Pores* small to very small, numerous to very numerous (19–45 per mm.^{2}), evenly distributed, mostly solitary, rarely in tangential or radial pairs ; vessel lines not prominent. *Soft tissues* usually indistinct under hand lens, when visible, appear as faint short tangential lines, often forming an irregular network with the rays. *Rays* of two classes – broad and fine – the former not distinct to the eye due to being almost of the same colour as the ground tissue, widely spaced, the latter just visible under hand lens, closely spaced ; radial flecks distinct.

The timber has not yet been tested for its physical properties. However, Desch gives the following data for *A. crassipes* Hook. f. from Malaya : Weight 43–55 lb., per c. ft. (sp. gr. approx. 0·69–0·88 air-dry). Seasons quite rapidly. Split rather badly, but surface checked only slightly. Can be sawn moderately easily and planes to a very smooth surface. Two sticks buried in the testing ground were attacked by fungi within 18 months and destroyed in 4 years.

Uses—At present it is mostly used locally. Probably a very useful building timber for framing, ceilings, flooring, etc., and might make good furniture (Desch). It may be suitable for plywood.

Material—

6253 Burma (0·64), 6691 Burma (0·72).

2. CAMELLIA L.

Small trees and shrubs distributed in tropical and sub-tropical parts of Asia. Of the 4 species indigenous in India 3 are dealt with here. Woods of these species cannot be differentiated with certainty. However, the single sample of *C. drupifera*, examined is heavy and pinkish to reddish-brown in colour, while the other two are moderately heavy and pale grey to light brown.

1. **C. caudata** Wall.—*phulkat* (Asm.), *hpa-lap, lapet, letpet, neng* (Burm.), *dieng-chi, dieng-tyrnem-synrang* (Kh.), *dieng-la-phyrno* (Synt.). A small evergreen tree 3·5–4·5 m. in height, with a clear bole of 1·5–1·8 m. and 30–60 cm. in girth. *Bark* greyish to reddish-brown, smooth, very thin.

It is found in Bhutan, in the evergreen forests of the plains of Assam and in the Khasi and Jaintia hills and the Martaban hills of Burma.

Description of the wood—See below.

2. **C. drupifera** Lour. (**C.** kissi Wall.)—*hpa-lap, lapet, letpet, neng* (Burm.), *dieng tyrnem-bhoi* (Kh.), *chasing, chau-kung* (Lep.), *hinguwa, kissi* (Nep.). A shrub or a small tree. *Bark* greyish-white, very thin.

It is found in the Himalayas from Nepal eastwards 1,200–2,100 m., hills of Assam, Manipur and Burma.

Description of the wood—See below.

3. **C. thea** Link. [**C.** sinensis (Linn.) O. Ktze.]—*cha, chah* (Hind.), *hpalan, lapet, letpet, neng* (Burm.). A shrub or a small tree sometimes up to 6–9 m. in height. *Bark* grey, smooth, very thin.

The tea plant is said to be indigenous in the evergreen hill forests of Assam and Burma, now extensively cultivated.

Description of the wood—See below.

Description of the wood
(*Camellia caudata, C. drupifera* and *C. thea*)

[P. **13**, 78 ; Pl. **14**, 79]

General properties—Wood, in *C. caudata* and *C. thea*, pale grey to yellow turning light brown on ageing, moderately hard and moderately heavy (sp. gr. 0·66–0·72 air-dry), but in *C. drupifera*, pinkish, turning reddish-brown with age ; hard and heavy (sp. gr. 0·92 air-dry) ; straight to twisted-grained ; very fine-textured.

Gross structure—A semi-ring-porous wood. *Growth rings* distinct, delimited by larger and more numerous early pores 1 to 10 rings per cm. *Pores* small to very small, visible only under hand lens, very numerous, unevenly distributed, early pores comparatively bigger and arranged in concentric rows, forming pore zones, transition from early to late wood usually gradual, mostly solitary, occasionally in oblique pairs, shape of the pores not distinctly visible under hand lens ; vessel lines not visible to the naked eye. *Soft tissues* usually indistinct, when visible, appear as faint, short tangential lines ; *Rays* fine to very fine, indistinct to just visible under hand lens in *C. caudata* and *C. thea* but usually more distinct in *C. drupifera*.

Uses—Straight branches make walking sticks and tool handles. The wood appears to be suitable for toy making.

Material—

C. caudata – 5615 Sibsagar, Assam (0·72).

C. drupifera – 3358 Darjeeling (0·92).

C. thea – 3143 Dehra Dun, U.P. (0·70), 5104 Darjeeling (0·66).

3. EURYA Thunb.

Small trees or shrubs, widely distributed in the tropical and temperate regions of both hemispheres. Four species have been reported to grow in the Indian region, of which 3 are available for study. Woods of these can not be separated.

1. **E. acuminata** DC.—*murmura* (Asm.), *hpunsi*, *lapet*, *shing-ling* (Burm.), *dien-pyrshit-heh*, *dien-shit* (Kh.), *flotungchong-jung* (Lep.), *bon-dousa*, *bon-sobai* (Mechi), *theng-han-jang* (Mik.), *sanu-jhingni* (Nep.), *dieng-la-pyrshit* (Synt.). A shrub or small-sized tree, sometimes up to 12 m. in height. *Bark* smooth, thin.

It is found in the temperate and sub-tropical Himalayas up to 2,400 m. elevation from Kumaon eastwards, in the plains and hills of Assam and hill forests of Burma.

Description of the wood—See below.

2. **E. japonica** Thumb.—*murmura*, *sanesi* (Asm.), *jhingin* (Beng.), *taung-lapet*, *taw-lapet* (Burm.), *yabi-chang* (Duff.), *chhamisi* (Garo), *pan-heng-heng* (Jharua), *hulini mukkorone* (Kan.), *dieng-pyrsit* (Kh.), *tungchong* (Lep.). A shrub or small tree up to 9 m. in height, clear bole 1·5–4·5 m. and 60 cm. –1·2 m. in girth. *Bark* grey-brown, with lines of lighter coloured small lenticels, thin.

It is distributed in the eastern Himalayas from Nepal eastwards, at 900–1,800 m., hills of Assam, Burma, South India and Ceylon.

Description of the wood— See below.

3. **E. symplocina** Blume—A large evergreen shrub to a small tree. *Bark* brown.

It is found in Sikkim and Bhutan at 1,500–2,100 m. elevation and in the hills of Assam and Burma.

Description of the wood—See below.

Description of the wood

(*Eurya acuminata*, *E. japonica* and *E. symplocina*)

[Pl. 14, 80]

General properties—Wood pinkish-white, turning yellowish to reddish-brown on ageing ; moderately hard ; moderately heavy (sp. gr. 0·57–0·69 air-dry) ; straight or slightly twisted-grained ; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct, sometimes concentric bands of fibrous tissues may, however, give the impression of growth marks. *Pores* small to very small, visible only under hand lens, very

numerous, (over 45 per mm.^{2}), evenly distributed, mostly solitary, occasionally in oblique pairs; vessel lines indistinct. *Soft tissues* indistinct under hand lens. *Rays* of two classes, broad and fine, the former just visible to the eye and distinct under hand lens, widely spaced and the latter just visible to indistinct under hand lens; some of the rays show up as fairly large flecks on the radial surface.

The timber is said to be easily worked and does not warp much.

Insect attack—*E. acuminata* is liable to be attacked by *Stenoscelis strigicollis* Mshll. (order Coleoptera), and newly cut logs of *E. japonica* by *Xyleborus* spp. (order Coleoptera).

Uses—Locally used for house posts and short poles. Appears to be suitable for toy making.

Material—

E. acuminata – 6623 Burma (0·63), 2320 Darjeeling (0·69).
E. japonica – 3876 Nilgiris (0·68).
E. symplocina – 385 Darjeeling (0·57), 3381 Darjeeling (0·62).

4. GORDONIA Ellis

Trees of this genera grow in India, South-East Asia, China and Formosa. Two species have been reported from the Indian region, of which one is dealt with here.

G. obtusa Wall.—*nagetta* (Nilgiris). A moderate-sized to tall evergreen tree. *Bark* grey, smooth.

It is confined to Western Ghats from Konkan southwards at an elevation of 700–2,100 m. common in the Nilgiris.

Description of the wood

[Pl. 14, 81]

General properties—Sapwood and heartwood indistinct in the material examined. Wood light reddish-brown; moderately hard; moderately heavy (sp. gr. 0·60–0·65 air-dry); straight-grained, fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* small to very small, numerous to very numerous (31–53 per mm.^{2}), mostly solitary, occasionally in oblique pairs; vessel lines not prominent. *Soft tissues* indistinct under the hand lens. *Rays* moderately broad to fine, just visible or not visible to the unaided eye, not closely spaced; radial flecks present.

The timber has not yet been tested for strength. It is reported to be liable to serious end splitting and warping, but with reasonable care this should not

be difficult to overcome. Green conversion and open stacking under shelter is advocated. It is also a little liable to stain. The timber is easy to saw and machine, and finishes to a good surface ; when cut on the quarter, presents a silver grain.

Uses—Due to clean appearance it is occasionally used for building purposes. It is suitable for internal construction and general joinery work and may also serve well for such articles as pen holders, foot rules and toys.

Material—

4607 Travancore (0·65), 6216 Coorg (0·60).

5. PYRENARIA Blume

The genus comprises of shrubs and small trees, which occur in India, South-East Asia, China and Philippines.

Besides the two species described, 2 more species have been reported from the Indian region. The woods are not distinguishable.

1. **P. camelliaeflora** Kurz—A tree 7·5–9 m. in height, with a clear bole 2·5–4·5 m. and 60–90 cm. in diameter.

It occurs in the drier hill forests of Martaban at 900–1,500 m. elevation.

Description of the wood—See below.

2. **P. serrata** Blume—A rather small evergreen tree, found in Tenasserim, Burma.

Description of the wood—See below.

Description of the wood

(*Pyrenaria camelliaeflora* and *P. serrata*)

[Pl. 14, 82]

General properties—No colour distinction between sapwood and heartwood. Wood light yellowish-brown with a greenish tinge ; moderately hard ; heavy (sp. gr. 0·59–0·69 air-dry) ; straight-grained, fine but somewhat uneven-textured.

Gross structure—Wood diffuse-porous to semi-ring porous. *Growth rings* distinct, demarcated by comparatively large and numerous early pores, 4–8 per cm. *Pores* rather small in early wood and in late wood very small, unevenly distributed, transition from early to late wood gradual, mostly solitary, occasionally in oblique pairs, mostly open but occasionally filled with whitish deposits. *Soft tissues* indistinct under the hand lens. *Rays* moderately broad to fine, the broad rays visible to the eye, widely spaced, the finer ones just visible under the hand lens ; radial flecks not prominent.

Uses—It appears to be suitable for turnery articles such as toys, pen holder, etc.

Material—

P. camelliaeflora – 6761 Burma (0·59).

P. serrata – 6393 Burma (0·69).

6. SCHIMA Reinw.

Trees of this genus are distributed in the South-East Asia, China, Formosa and the Philippines. Of the two species growing in India, one was available for study. The other *S. khasiana* Dyer., is a large tree of the Khasi hills, Naga hills and Manipur.

S. wallichii Choisy—**chilauni**, *nogabhe* (Asm.), *kanak*, *makrisal* (Beng.), *bonak* (Cach.), *daak-shing* (Chin.), *kanak*, *makrisal* (Hind.), *kamsuri* or *kamsuri-phang* (Kach.), *dieng-ngan* (Kh.), *kayothat* (Kn.), *man-khing*, *man-thiang* (Kuki), *sambrang-kung* (Lep.), *gugra* (Mechi), *cheknan-arong*, *chingan-arong* (Mik.), *ingkhia-ching* (Naga), *chilaune* or *sule chilaune* (Nep.), *rangi-rata* (Sylh.), *dieng-shyr-ngan* (Synt.), *mankhing-thing* (Tipp.). A large evergreen tree up to 27 m. in height and 3·5 m. in girth. *Bark* black or dark grey with deep vertical cracks.

It is found in the sub-Himalayan tract from Nepal eastwards ascending to 1,500 m., Khasi hills, Manipur, Chittagong hills and upper Burma.

Description of the wood

[Pl. **14**, 83]

General properties—Sapwood light greyish-white ; heartwood light red to reddish-brown ; moderately hard ; moderately heavy (sp. gr. 0·56–0·74 air-dry) ; straight to twisted-grained ; medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker bands of fibrous tissue 1–6 per cm. *Pores* moderately large to small, numerous (24–42 per mm.^{2}), evenly distributed, mostly solitary, occasionally in oblique pairs, oval to angular, occasionally filled with tyloses. *Soft tissues* indistinct under the hand lens. *Rays* fine to very fine barely visible under hand lens, somewhat closely spaced, evenly distributed.

Strength—See appendix I.

Seasoning—Difficult to season. For air seasoning green conversion followed by stacking under cover is recommended. Kiln drying gives much better result.

Natural durability—Not durable, lasts for 34–65 months in contact with the ground.

Insect attack—Logs are liable to be attacked by *Rhadi nomerus maesae* Mshl. (Family Curculionidae) and *Platypus indicus* Stroh. (Family Platypodidae), both belonging to the order Coleoptera. White ants also destroy it easily. The timber is prone to the wood rotting fungi *Fomes lamaoensis* Murr., and *Polyporus dichrous* Fr., which cause honey-combed rot and white rot respectively.

Preservative treatment—Heartwood refractory to treatment, incision is necessary for 1 to 2 cm. penetration.

Working qualities—It is easy to cut and saw and takes a good polish. It is, however, not liked by carpenters and saw millers because it causes irritation to hands when handled.

Supply and uses—Large quantities are available from North Bengal and Assam. It is mostly used locally for house building and agricultural implements. It has proved to be an excellent wood for plywood, suitable for tea chests.

Material—

491 Darjeeling (0·68), 636 Assam (0·68), 646 Darjeeling (0·63), 1449 Mishmi hills, Assam (0·72), 5479 Kurseong, Bengal (0·56), 5670 Cachar, Assam (0·74), 5798 Buxa, Bengal (0·74), 6437 Burma (0.73), 7261 Nowgong, Assam (0·65), 7264 Kurseong, Bengal (0·65), 7279 Goalpara, Assam (0·71), 7328 Jalpaiguri, Bengal (0·77), 7353 Jalpaiguri, Bengal (0·73), 7556 Kamrup, Assam (0·70), 7578 Kamrup, Assam (0·71), 7600 Assam (0·70).

7. TERNSTROEMIA L.

Trees and shrubs which are widely distributed in tropical America, Asia and Africa. Two species have been reported from the Indian region.

Since single sample of *T. penangiana* was available for study, it was thought advisable not to give a key for the separation of the species. However, the wood of *T. penangiana* is heavier and coarser than *T. japonica*. The pores in *T. penangiana* are moderately large, while those in *T. japonica* are small to very small.

1. T. japonica Thunb.—*pani-bokul, pani-jikiri* (Asm.), *taungkan* (Burm.), *kamoni, kaymone, kiamonu* (Kan.), *dieng-la-saw* (Kh.). A large tree up to 24–27 m. in height with a clear bole of 12–15 m. and 1·5–2 m. in girth. Reported to be not so tall at high elevations. *Bark* brown or grey, 1·25 cm. thick, warty.

The plant is found in Sikkim at 2,100–2,400 m. elevation, Khasi hills, Burma and Nilgiris, also in Ceylon, Sumatra, China and Japan (Brandis).

Description of the wood—See page 94.

2. T. penangiana Choisy—*taung-bok* (Burm.). An evergreen tree, 15–24 m. in height, with a clear bole of 9–12 m. and 1·8–2·1 m. in girth.

It is found in the Andamans and Tenasserim, also in Malay peninsula, Cochin China.

Description of the wood—See below.

Description of the wood

(*Ternstroemia japonica* and *T. penangiana*)

[Pl. 14, 84]

General properties—Sapwood whitish, heartwood reddish-brown ; moderately hard ; moderately heavy (sp. gr. 0·58–0·80 air-dry) ; straight to slightly twisted-grained ; fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct to indistinct, delimited by darker bands of fibrous tissues, about 4 rings per cm. (Desch did not observe growth rings in *T. penangiana*). *Pores* moderately large (In *T. penangiana*) to small (in *T. japonica*), numerous in *T. japonica* (over 38 per mm.^{2}), but moderately numerous in *T. penangiana* (about 18 per mm.^{2}), evenly distributed, mostly solitary, occasionally in radial pairs, open. *Soft tissues* indistinct under the hand lens. *Rays* of two size classes, broad and fine, the former visible to the eye, widely spaced, the latter barely visible under hand lens, fairly closely spaced ; some of the rays show up as fairly large flecks on the radial surface.

The timber has not been tested for its physical properties but Gamble states that it requires careful seasoning.

Uses—It is locally used for building purposes and general joinery work. Before World War II, it used to be imported in Bombay and sold as 'Java teak', because of its cheap price. Very little timber from forests of India comes to big timber markets.

Material—

T. japonica – 3890 Nilgiris, Madras (0·62), 3750 Nilgiris, Madras (0·76).

T. penangiana – 7106 Burma (0·79).

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S. K. PURKAYASTHA.

14. SAURAUIACEAE

A mono-generic family of trees and shrubs which occur in tropical and sub-tropical regions of Asia and America.

The family is not so important from the point of view of timber. Four out of 9 species indigenous in India are dealt with here.

SAURAUJA WILLD. (SAURAUIA WILLD.)

1. **S. griffithii** Dyer—*hlosiphakung* (Lep.), *gogen*, *gogum* (Nep.). A shrub or a tree 4·5–6 m. in height with a clear bole of 1·5–3 m. and 30–90 cm. in girth. *Bark* grey-brown with prominent corky lenticels, thin.

It occurs in the Sikkim Himalayas from 1,200–1,800 m. and also in Goalpara in Assam.

Description of the wood—See page 97.

2. **S. nepaulensis** DC.—*gogan*, *gogana*, *goganda*, *gogea*, *gogina*, *pangara* (Hind.), *ratendu* (Jaunsar), *kasur-kung* (Lep.), *gogen* (Nep.). A small tree 6–9 m. in height with a clear bole of 1·5–3 m. and 30–90 cm. in diameter. *Bark* reddish-brown, smooth, thin.

It is found in the Himalayas from the Jumna eastwards from 750–2,100 m. elevation and in the hills of Assam.

Description of the wood—See page 97.

3. **S. punduana** Wall.—*maraw*, *numraw patok* (Burm.), *dieng-ja-ngap*, *dieng-soh-khijut*, *dieng-soh-la-pot* (Kh.), *safar* (Lep.), *gaban*, *rate-gegun* (Nep.), *dieng-la-kampied*, *dieng-soh-la-pied* (Synt.). A small tree 9–12 m. in height, with a clear bole of 2·5–4·5 m. and girth 80 cm.–1·1 m. *Bark* dark brown, vertically cleft with prominent lenticels.

It occurs in Sikkim, terai and outer valleys, ascending up to 1,800 m. and in the hills of Assam and Burma.

Description of the wood—See page 97.

4. **S. roxburghii** Wall.—*bon-posola*, *hengunia paniposala*, *parbotia-sengunia* (Asm.), *maraw*, *numraw*, *patok*, *shiel-lay*, *thit-ngayan* (Burm.), *chepu-change*, *chipung-change* (Duff.), *bor-jir-sinning* (Garo), *bon-loisu-phang* (Kach.), *dieng-soh-la-pied* (Kh.), *safar-kung* (Lep.), *terpui* (Lush.), *sing-khrau* (Manip.), *deibru* (Mechi), *nonthler-arong* (Mik.), *dia-ching*, *tong-bahu* (Naga), *aule gogun*, *gogan* (Nep.), *arbeng-thing* (Tipp.). A small tree up to 9–12 m. in height with a clear bole of 3–6 m. and 90 cm.–1·2 m. in girth. *Bark* reddish-brown, thin.

It is found in Sikkim, terai and outer valleys, ascending to 1,200 m. elevation, throughout Assam, Chittagong, and in the hill forests of Burma.

Description of the wood—See below.

Description of the wood

(*Saurauja griffithii*, *S. nepaulensis*, *S. punduana* and *S. roxburghii*)

[Pl. 15, 85]

General properties—Wood yellowish to pale brown; soft; light (sp. gr. 0·37–0·53 air-dry); straight to slightly twisted-grained; medium fine-textured.

Gross structure—Wood diffuse-porous. *Growth rings* indistinct, occasionally darker bands of fibrous tissues may, however, give the impression of growth rings. *Pores* moderately large to small, just visible to indistinct to the eye, moderately few to numerous (8–30 per mm.^{2}), more or less evenly distributed mostly solitary, rarely in radial or oblique pairs, oval; vessel lines inconspicuous. *Soft tissues* indistinct under hand lens. *Rays* moderately broad to fine to very fine, usually not very distinct to the eye, due to very little difference in colour with the ground tissue, closely spaced, evenly distributed, radial flecks present but not prominent.

No information is available regarding the physical properties and working qualities of these species. According to Record and Hess, the timber of American species, is "easy to cut, saws finely woolly, is rather hairy under the plane; probably not durable". Kanehira mentions that the Formosan species is subject to decay.

Uses—It is mostly used locally. It is suitable for interior construction of minor type. It may also serve well for packing cases and the like.

Material—

S. griffithii – 5462 Buxa (0·49), 5563 Kurseong (0·41).
S. nepaulensis – 2321 Darjeeling (0·37).
S. punduana – 5463 Buxa (0·53).
S. roxburghii – 3271 Duars (0·48).

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S. K. PURKAYASTHA

15. DIPTEROCARPACEAE

It is a large family, consisting of 18(?) genera and about 450 species of small to big to very big trees. Shrubs are rarely met with. Members of this family are mostly confined to tropical Asia and have received considerable attention from both systematists and anatomists because of their economic importance. Even then the position of some of these remain uncertain. As a result, the conception of generic and specific limits is still undefined and the number of species in existence has assumed a speculative figure. Since its establishment, *Ancistrocladus* and *Lophira* have been removed from the family, and the genera *Monotes* and *Marquisia* of Africa, *Dioticarpus* of South India, and *Upuna* of Borneo have been added to it. In 1839–42, Korthals recorded only 34 species, while De Candolle (1868) gave the figure as 126. Dyer (1874) estimated and gave the figure as 170 and Brandis (1894) by actual enumeration put the species as high as 325. In 1923 Merrill after certain reductions and transfers, raised Brandis's figure to 377. Recently Foxworthy (1946) estimated the total number of species to be 450. But according to Symington, more than 200 species have actually been found out during the last sixty years, and to make a correct estimate of the total number of valid species in the family, considerably more research would be necessary. As to the number of genera, it was Heim who summarized the systematic aspect of works done before him. Bentham and Hooker gave 12 genera, De Candolle, 14 genera, Burck, 10 genera and Heim himself 30 genera. Later Brandis in his important paper on "An enumeration of the *Dipterocarpaceae*" published in the Journal of the Linnean Society in 1895 gave 5 tribes and 16 genera. In the early part of this century, Merrill made a fresh survey and recorded 17 genera. More recently Symington and Foxworthy have shown the total number of genera to be 18. Desch, who made a comprehensive study of the woods of Malayan dipterocarps, has recognized 15 divisions or groups based on anatomical features. In this grouping he did not consider, *Doona*, *Dioticarpus* and *Vateria*. However, on anatomical grounds it is felt that though Symington and Desch have clarified and redefined some of the unstable genera, there still remains much to be done to get a clear idea of all the genera that the family contains.

Balanocarpus, which once comprised of as many as 22 species, has now been reduced to such an extent by Symington and others that it contains only two species. The rest have been transferred to *Hopea* and *Shorea*. Even these two, i.e., *B. heimii* King of Malay Peninsula and *B. brevipetiolaris* Thw. of Ceylon have been kept under anomalous *Balanocarpus* for the present with the remark that these have no claim for the name. Similarly *Dioticarpus* which was established by Dunn in 1920 has been transferred recently by Bole to *Hopea*. This appears to be in order from anatomical point of view. Both

Monoporandra and *Pachynocarpus* do not have the status of genus now, and been rightly merged with *Vateria* and *Vatica* respectively by Symington. *Stemonoporus* has so far been recognized as a distinct genus but it is doubtful whether it will be able to maintain its status as such. Already systematists have started placing *Stemonoporus* along with *Vateria*. From anatomical point of view this appears to be more probable. Similarly *Isoptera* which was considered by some to be a distinct genus has now been put under *Shorea*. The monotypic endemic genus *Vateriopsis* of Seychelles island, which was previously regarded by some authorities as distinct, is now considered only to be a form of *Vateria*. Another genus *Pentacme* needs careful investigation. The anatomical structure of *Pentacme suavis* and *Shorea obtusa* both of Burma, has been found to be very similar and almost indistinguishable. Here is a field of research by systematist and anatomist to find out whether these two species have enough difference to be classified as distinct species or their characters are so overlapping that lumping would be desirable.

The distribution of dipterocarps, though mainly Indo-Malayan, covers a wide area ranging from Africa on the west and the Philippines and New Guinea in the east. Foxworthy has given six main regions of distribution :— (1) Africa ; (2) Ceylon ; (3) India (Western Peninsula up to Assam) ; (4) Eastern Peninsula or Further India (including Burma, Thailand, Indo-China and Tropical China) ; (5) Western Malaysia (Malay Peninsula, West of Wallace's line and the Philippine islands) ; and (6) Eastern Malaysia (Malay Peninsula, East of Wallace's line and up to New Guinea). The world distribution of genera and species according to Foxworthy is given in Table I.

From the Table I, it will be seen that members of the family *Dipterocarpaceae* are now located in areas which are separated by many seas. Yet according to some authorities, all these members were once growing together on a single mass of land which now stand scattered due to geological action of the past. How far this theory is correct we do not know because paleobotanical data so far available do not allow any such definite conclusion. All the same there are many points which come out of the table given below. For instance, the family is restricted only in tropical Asia and does not extend either into tropical Australia or America. Moreover, certain genera are remarkable for their wide distribution while others show very restricted distribution. *Monotes* and *Marquesia* are restricted to only Africa while *Doona* and *Stemonoporus* to Ceylon. Again *Vateria* grows only in Ceylon and South India. Another remarkable species is *Vateria seychellarum* Dyer, which occurs only in Seychelles islands. Similarly *Dryobalanops* is found in Malay Peninsula, Sumatra and Borneo, while *Upuna* in Borneo alone. The genera which have wide distribution are many, particularly *Shorea*, *Dipterocarpus*, *Hopea* and *Vatica*. The distribution of *Cotylelobium* is remarkable as only one species is said to grow in Ceylon and the rest from Thailand to Borneo.

Again distribution of species within a genus is no less interesting. *Dipterocarpus gracilis* Blume (*D. pilosus* Roxb.) occurs from Chittagong hill tracts, Andaman islands, Burma, Malay Peninsula, Sumatra, Java, Borneo and up to the Philippines. *D. grandiflora* Blanco. behaves almost the same way. Again, one of the shoreas namely *Shorea guiso* (Blanco.) Blume covers a very wide area starting from Indo-China to Thailand to Malay Peninsula, Borneo to the Philippines. *S. talura* Roxb. which was reported to be confined to South India, has now been found to have a wide distribution, extending to Burma, Indo-China, Thailand and Malay Peninsula. Among the Indian species, limited distribution is to be found in the cases of *Dipterocarpus bourdilloni* Brandis, *D. indicus* Bed., *Hopea glabra* W. & A., *Shorea tumbuggaia* Roxb *Vateria indica* Linn., and *Vatica roxburghiana* Blume, all of South India. *Hopea shingkeng* (Dunn) Bor is another example of very limited distribution in Assam.

TABLE I.—*Geographic distribution of the genera and species of Dipterocarpaceae*

Genus	Total spp.	Africa	Ceylon	India	Further India	Western Malaysia	Eastern Malaysia
Anisoptera	13	..	..	..	2	12	2
Balanocarpus	1	..	..	..	..	1	..
Cotylelobium	5	..	1	..	..	4	..
Dioticarpus	1	..	..	1	..	..	..
Dipterocarpus	73	..	5	2	16	58	..
Doona	12	..	12	..	..	..	..
Dryobalanops	9	..	..	..	..	9	..
Hopea	73	..	4	8	13	49	4
Marquesia	3	3	..	..	..	..	..
Monoporandra	2	..	2	..	..	..	..
Monotes	31	31	..	..	..	..	..
Parashorea	8	..	..	..	2	7	..
Pentacme	3	..	..	..	1	3	..
Shorea	131	..	5	3	20	107	3
Stemonoporus	14	..	14	..	..	..	..
Upuna	1	..	..	..	..	1	..
Vateria	5*	..	2	2	..	..	..
Vatica	65	..	3	1	11	52	3
Total ..	450	34	48	17	65	303	12

*Includes *Vateria seychellarum*, which does not fit exactly into any of the regions and is not included in the other columns.

Furthermore, it will be seen that the largest genera are *Shorea* with 131 species, *Dipterocarpus* with 73, *Hopea*, 73, *Vatica*, 65, and *Monotes*, 31. There is also a tendency for members of this family to concentrate in western Malaysia where about 303, that is, about two-third of the total species occur. However, the richest areas appear to be Borneo with 153 species, and Malay Peninsula, a close second with 141. From these facts Symington has been led to draw the conclusion that probably Borneo and the adjacent region is the original home or the centre of distribution of this family.

It will also be seen that the family is strikingly tropical. However, its distribution is somewhat restricted by elevation. In India and in the entire region from Malay Peninsula to New Guinea and the Philippines, dipterocarp forests occur in comparatively low altitudes and usually below 600 m., except in the case of *Shorea robusta* and two species of *Dipterocarpus* which reach about 1500 m. or little over.

The extreme north-eastern limit of the family which is more or less on the outer fringe of the tropics is China where one lonely species of *Hopea* grow in Kwangtung and another one of *Vatica* in Hainan. The north-western limit is reached by *Shorea robusta* which at the moment is limited to Hoshiarpur in the East Punjab.

Dipterocarps mainly occur in tropical evergreen and well-drained rain forests, preferring more of soil moisture and high humidity. Usually they cannot thrive in swampy soil or water-logged condition except a few species such as *Anisoptera marginata* Korth of Malay Peninsula, *Dipterocarpus dyeri* Pierre of Burma, *Dryobalanops rappa* Becc. of Borneo, *Shorea teysmanniana* Dyer of Sumatra, and *Vatica wallichii* Dyer of Malay Peninsula. Among xerophytic species, *Shorea robusta* and *S. talura* may be cited as examples. Both are capable of standing fires, but only sal can withstand frost.

The distribution of dipterocarps at the present time is said to be linked with the geological history of the region. Bancroft and Symington have given an outline of this, based on their study of the present and the past flora of the family. Fossil records do not yet give a complete picture of its past distribution but it can be said without contradiction that the family was in existence about 70 million years ago in South-East Asia during the Middle Tertiary Period. All these information is based mainly on the identification of fossil woods that have so far been studied. An analysis of all results of investigation so far carried out by various workers shows that sometimes in the early part of Tertiary Period, the members of this family started spreading from somewhere near western Borneo. The process of spreading was on all the four directions. After reaching Borneo through Indo-China and Thailand, its spread to India and Ceylon was by way of Burma and the present Bay of Bengal. The presence of endemic genera like *Doona* and *Stemonoporous* in Ceylon is

said to be due to the separation of the island from the Indian mainland in early Pleistocene. As regards the presence of fossil woods of this family in Africa, two theories have been advanced – one is that they have reached Africa from South India by way of a southern route through Seychelles and Madagascar, and the other is a more northernly route following a north-western land passage which connects Asiatic continent with Africa. In this way it is believed that towards the end of the Tertiary Period, the family members established themselves in the localities they are found at present. Recent researches carried out in this laboratory show that they have shifted hundreds of miles from the place they were growing 70 million years ago.

While talking about the fossil woods of the family *Dipterocarpaceae*, it may be pointed out that the form-genera created by some workers require careful re-examination. Three form-genera are in existence, viz., *Dipterocarpoxylon*, *Dryobalanoxylon* and *Shoreoxylon*, each of which includes fossil woods whose matching with the living woods can not be said to have been always very accurate. The name *Dipterocarpoxylon* when applied in the sense that the fossil belonged to the family *Dipterocarpaceae* is the safest. Advisability of using the other two form-genera is questionable. Based on our work in this laboratory, we suggest that a classification somewhat on the line indicated in the key for genera included in this book is likely to remove the confusion that now exists in the classification and identification of fossil woods of this family.

The most outstanding anatomical structure of the family is the presence of gum canals in all parts of plants and at all stages of growth. It is found in the embryo, cotyledons, petioles, midribs, and veins of leaves, flowers, fruits, roots, barks and woods. It is very conspicuous in the early stages due to the schizo-lysigeneous nature of development. In the young axis, groups of cells appear blocked out due to dense cytoplasmic nature of the cells. These are the cells which subsequently form the gum canals and often indicate the places where some of the first xylem elements arise. In the pith, the gum canals are arranged almost in a concentric row towards the periphery. They vary to a great extent in their size, shape and number. In the pith there may be as many as 100 in *Dipterocarpus*, 25–60 in *Vateria* (including *Stermonoporus*), 3–30 in *Shorea*, 12–25 in *Pentacme*, 18–24 in *Anisoptera*, 10–20 in *Vatica*, 15 in *Parashorea*, and 3–20 in *Doona*. But in *Dryobalanops* and some hopeas, the gum canals are not usually many and may be sometimes as low as 1 and 4 respectively. In *Dryobalanops*, resin canals occur more or less in the centre of the pith but in the rest of the family they are arranged on the outer periphery of the pith. In the secondary xylem vertical canals are variously arranged. They may be solitary or in short tangential groups of 1–8 or even more or in concentric rows for a considerable distance, if not all round the tree. The first type is a characteristic feature of certain genera and is, therefore, helpful

in the classification of woods of this family. The second type, which looks traumatic in origin, occurs in all the members of this family, occasionally including the genera in which the first type is formed. As regards horizontal canals, they occur only in some shoreas.

In the cortex, gum canals are associated with leaf-traces which are usually three in number – one apical and two lateral. In the characteristic bifacial structure of the petioles, gum canals are arranged in a somewhat semi-circular fashion. Each peripheral bundle usually have one gum canal. Inside this arc of vascular bundles, there is either a large central bundle or several of them where gum canals may be present or absent. In various genera, the total number of these petiolar gum canals varies to a great extent. An intensive study of this variation is necessary to understand the affinity of different genera. The result may lead to the removal of confusion that now exists regarding the generic position of some members. Data so far available on the outer and inner vascular bundles are given in the table below :—

TABLE II.—*Number of gum canals in petioles of certain genera of Dipterocarpaceae*

Genus	Outer vascular bundles	Central or inner vascular bundles
Anisoptera ...	7–13	Nil or few
Dipterocarpus ...	5–12	1–8
Doona ...	3–11	Nil–1
Dryobalanops ...	5	Nil
Hopea ...	3–5	Nil–3
Pentacme ...	7–9	3
Shorea ...	7–12	Nil–3 or more
Parashorea ...	5	Nil
Stemonoporus ...	4–6 and 9–12 (in two arcs)	Nil–11
Vateria ...	10–15	3–7
Vatica ...	3–10	Nil or few

Apart from timber, the family is of some importance from the point of view of other products that it gives. The more well-known of these is Borneo camphor which is obtained from the trees of *Dryobalanops aromatica* Gaertn. f. This camphor remains deposited in the inter-cellular canals or pockets along with the oleo-resin showing up as colourless or light yellow crystals. This camphor which is crystalline in the natural state is rare and more costly as compared with the product which is obtained after wounding the trees. It

is said that in the past, one of the important uses of the Borneo camphor had been for the preservation of dead bodies of high dignitaries. It is also used as a substitute for true camphor (*Cinnamommum camphora* Nees and Eberm.) particularly in China and Japan, where it is extensively used for medicinal and other purposes. Essential oils such as dipentene, camphene, borneol have been isolated from the resins or wood oils from *Dryobalanops aromatica* Gaertn. f., and gurjunene from *Dipterocarpus turbinatus* Gaertn. f., *D. tuberculatus* Roxb. and others.

Seeds of many dipterocarps are rich in oils and fats. The well known fat of the trade, known as tangkawang or Borneo tallow comes from the seeds of *Shorea aptera* Burck., *S. stenoptera* Burck. and others. In Europe, this tallow is used for soap making and in the candle industry while in South-East Asian countries mainly as food. This is also used for chocolate making in place of cocoa butter. Amongst the Indian trees *Shorea robusta* Gaertn. f., and *Vateria indica* L., yield fatty and starchy seeds.

Except *Monotes* and *Marquesia* all dipterocarps produce oleo-resin. This has been taken advantage of by developing resin-tapping in the forest of many countries, particularly Malay Peninsula. Although resin is always present in the bark and wood of many, yet only a few trees produce resin in sufficient quantity. Amongst those which yield dammar of commercial value are such genera as *Shorea*, *Vateria*, *Hopea* and *Balanocarpus*. In Malaya *Balanocarpus heimii* King (damar penak), *Hopea micrantha* Hk. f., and *Shorea hypochra* Hance (damar temak), in Java and Sumatra *Shorea wiesnari* Schiftn. and in India *Shorea robusta* and *Vateria indica* are well known for the damar they yield. Dipterocarp species like *D. tuberculatus*, *D. turbinatus* and many other Burmese and Malayan ones yield what is commonly known as *gurjun balsam*, *balao balsam*, and *malapaho balsam*. Their chief uses are for paints, caulking boats, and preservatives. Locally these are also reported to be used for medicinal purposes.

Methods of tapping have been shown by Foxworthy in several trees of Malay Peninsula and these have been adopted more or less elsewhere. Usually a semi-circular cut is made through the entire bark and cambium and a portion of the wood. Further blazings are made at intervals to refresh the resin-clogged dried portions of the cut surface. This periodical blazings help the flow of the oleo-resin. In each tree a number of such cuts are made at several places taking care that the blazes or wounds are not too closely spaced so as to damage the trees badly. Careless and continuous blazings all round the bole have sometimes led to the girdling of the trees causing their ultimate death in many cases. Some of the Malayan trees which are often tapped for oleo-resin are *Anisoptera thurifera* Blume, *Balanocarpus heimii* King, *Dryobalanops oblongifolia* Dyer, *Shorea acuminata* Dyer, *S. leprosula* Miq., and *S. parvifolia* Dyer. A good

yeilder is reported to produce 40–50 lb. (approx. 18–23 kgms.) of dammar a year, though normally an average tree does not produce more than 10–15 lb. (approx. 5–7 kgms.) annually. In the case of keruing (*Dipterocarpus scortechinii* King), the tapping is said to be done by making a hole in the trunk and setting fire to it repeatedly. This may raise the yield initially but would appear to shorten the life of the trees.

The leaves and barks of many dipterocarps contain tannin. For example, *Dipterocarpus turbinatus* has 7% tannin in bark and leaves ; *D. tuberculatus*, 24% in bark ; *Hopea odorata*, 14% in bark, 11% in leaves, 12% in wood ; *H. parviflora*, 14–28% in bark ; *Shorea robusta*, 9·1% in bark, 7% in leaves, 20% in young leaves, and 22% in young twigs and leaves. Occasionally bark of certain species may be used for other purposes. In the case of *Dryobalanops aromatica* Gaertn. f., the bark can be removed in large sizes, and used for walls, roofs, floors, beds, and sometimes for making baskets, etc.

This family plays a great part in the economy of the countries of South-East Asia, where it provides timber in abundant quantities and showing considerable variation in weight, texture, grain and colour. In fact in some countries the output of timber from this family is more than half of the total output of the forest. Another advantageous point found in some of the members of this family is that they grow gregariously often in a pure crop. This gives an opportunity for using modern technique in felling and extraction of timber at an economic cost – a practice not always possible in tropics where most of the species grow in a mixture.

Many of these timbers are so good and suitable for specific purposes that they are sought after in other countries. This applies for sal, *gurjun*, *thingan* and *thingadu* of India, Pakistan and Burma. The same also applies to *balau*, *meranti*, *keruing*, *mersawa*, *chengal* of Malay Peninsula and *yang*, *chan*, *krabak* of Thailand ; *seraya* and *kapur* of Borneo and *luan* of the Philippines. Though majority of the timbers are non-ornamental, there are a few which are handsome and resemble mahogany. This has led to calling some dipterocarp woods of the Philippine Islands as Philippine mahogany. To avoid confusion in the trade such a practice should not be encouraged.

The timbers are mainly used for all types of constructional work due to high strength properties and natural durability. Some strong, heavy and durable timbers like *Shorea*, *Hopea*, *Balanocarpus* are suitable for railway sleepers, bridges and wharf construction, heavy structural work, rafters, beams, posts, poles, joints, boat building, dug-outs and piles. Timbers not so hard and heavy are used for a variety of purposes such as house-building, doors and windows, framings, carriage and wagon building, rough furniture, carts, wells, tool handles, ploughs and many others. The softer and moderately heavy timbers especially shoreas of the Malay Peninsula and others are very good

for light and handsome furniture, cabinets, boarding, interior joinery and finishings, shop fittings, panelling, packing cases, veneers and plywood. Meranti is reported to be used for organ pipes and chinese coffins. *Shorea bracteolata* is reported to be suitable for wooden barrels for palm oil, while *Shorea kunstleri* has been used in the mines for its good wearing qualities. In short the woods of this family show a great range of variation in anatomical structure and physical properties, thus making them suitable for many purposes. Actual uses to which timbers of this family are put throughout the countries where they grow are far too many to be enumerated here.

Some attempts have been made to grade timbers of this family with a view to ensuring quality for the users whether at home or abroad. This very fact indicates the importance and the usefulness of the timbers of this family in the world market.

From anatomical point of view the woods of this family have some characteristic structure. The most important diagnostic feature of the family is the occurrence of vertical gum canals except in *Monotes* and *Marquesia*. The prevalence of gum or resin is also responsible for imparting resinous odour to many of the woods. The gum canals in many timbers are often filled with whitish deposits which make them conspicuous. Various shades of colour, ranging from whitish-grey or grey, brown, or yellowish-brown, pink, reddish-brown to red, characterise the woods. Some of them are decidedly lustrous and show good figure, or ribbon-grain effect while many others look very drab and dull. In texture also they show a great variation.

Growth rings are indistinct in most timbers so much so that the counting of growth marks is not feasible. There are a few exceptions no doubt, but in such cases the reliability may not be very high unless checked under the microscope. Pores are very variable in size, very large and distinct to the eye to very small and not visible at all ; tyloses are sometimes very characteristic and in several timbers almost completely fill up the pore cavity making such timbers not amenable to any preservative treatment. Soft tissues are conspicuous in many of the timbers as diffuse to irregular reticulum to vasicentric type. The latter may be abundant round the pores and form many patterns like a thin sheath, conspicuous to inconspicuous eyelet, or wing-like to aliform, to confluent as thin layers linking up vessels. The wood fibres in hard and heavy timbers are usually small in diameter with thick walls while in soft woods, fairly large in diameter and thin-walled. Gum canals of the vertical type may be solitary or in short tangential arcs and more or less in concentric bands. Radial gum canals are present only in some shoreas (*Richetia* section of *Shorea*) but this has not been observed in any *Shorea* from India. Rays are very variable in width. They may be broad and very deep in some, while in others moderately fine to fine and shallow in depth. Ripple marks are absent in the

majority of the woods and only in few species like *Balanocarpus*, *Hopea*, and *Shorea* may be present locally*.

The family is represented in the Indian region by about 10 genera and 50 species. It is not always possible to distinguish all the genera under the hand lens. They can, however, be separated as given below :—

Key to the genera

1. Gum canals always present in short rows, often broken but uniformly distributed all over the wood ... 2

1. Gum canals absent, or when present usually in long concentric bands rather irregularly distributed ... 5

  2. Gum canals usually solitary, minute, appearing like white dots 3

  2. Gum canals rarely solitary, mostly in short tangential groups, 2–8 or more. Wood brown to reddish-brown, often with resinous odour ; coarse-textured, dull ... ... *Dipterocarpus*

3. Wood white or yellowish to greyish-brown ; soft to moderately soft, moderately heavy, rather coarse-textured 4

3. Wood brown to reddish-brown or grey, heavy to very heavy, rather fine-textured ... ... *Vatica*

  4. Pores moderately large, mostly solitary. Soft tissues abundant, mainly diffuse. Gum canals rather scanty ... ... *Anisoptera*

  4. Pores small, often in pairs or clusters of 2–5, sometimes arranged in oblique rows. Soft tissues not profuse, usually distinct round the pores or pore groups. Gum canals numerous ... ... *Vateria*

5. Ripple marks present ... ... *Balanocarpus*, *Hopea* in part.

5. Ripple marks absent 6

  6. Pores fairly large to large, usually distinct to the eye. Wood rather coarse-textured ... 8

  6. Pores small to extremely small, indistinct to the eye. Wood rather fine-textured 7

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* Some features which are usually visible under the microscope have importance in identification and utilization are :—(1) *Sheath cells* have been observed in some wood (*Anisoptera*) and conspicuously high and low cell in the ray composition of all hopeas (including *Balanocarpus* and and *Dioticarpus*), (2) *Crystals* in the soft tissues have sometimes been reported in *Dryobalanops*, *Parashorea*, *Pentacme* and *Shorea* ; and sometimes in rays of *Cotylelobium*, *Pentacme*, *Hopea* and *Balanocarpus*. Silica deposits are also known to occur in *Anisoptera*, *Cotylelobium*, *Dipterocarpus*, *Dryobalanops* and certain shoreas.

7. Soft tissues mostly apotracheal, diffuse or forming irregular net-work. Pores mostly open, seldom form oblique groupings ... ... *Hopea* in part (Hard).

7. Soft tissues mostly paratracheal, vasicentric or aliform. Pores often show oblique groupings ... ... *Balanocarpus, Dioticarpus, Hopea* in part (Very hard).

8. Soft tissues mostly forming prominent eye-lets round the pores. Pores not plugged with tyloses. Wood moderately heavy, lustrous ... ... *Parashorea, Shorea* in part (Moderately hard).

8. Soft tissues abundant, vasicentric and diffuse arrangement prominent. Pores often plugged with tyloses. Wood heavy to very heavy, not lustrous ... ... *Pentacme, Shoreas* in part (Hard).

1. ANISOPTERA Korth.

The genus *Anisoptera* contains about 32 species, which are widely distributed starting from Chittagong, East Pakistan on the west and spreading up to New Guinea in the Pacific. The largest number of species, however, occurs in the Malay Peninsula, Sumatra and Borneo. The genus consists of moderately to very large-sized trees up to 46 m., high, found in the evergreen as well as the deciduous forests. It grows from sea-level to 850 m. elevation. The fossil records show that members of the genus were growing over much more extensive area than they do now. The two species now growing in the Indian region are confined to Chittagong and Burma while during Middle Tertiary, some anisopteras formed forests in West Bengal (Ranigunj) and Garo Hills.

Like other dipterocarps, the gum ducts are present in all its parts, e.g., root, stem, petiole, leaf and flower. In the wood they are widely dispersed either singly or in concentric rows. The timber is light coloured, from yellowish-grey to yellow-brown to even rose-red. The commercial uses of the timber is not so extensive as it should be because of its good quality and the large sizes in which it is available. The trees yeild also a dammar which, however, at present has no commercial value.

The Indian region has only two species namely *A. oblonga* and *A. scaphula*. Anatomically woods of these are often indistinguishable but occasionally can be separated by the following characters :—

1. Wood pale yellow to light yellow-brown to brown. Single gum ducts more frequently visible to the eye, easy to spot with a lens ; white deposits mostly fill up the gum ducts. Rays mostly broad, fine rays inconspicuous and less common in between the broad rays ... ... *A. oblonga*
2. Wood yellowish to brown, occasionally rose-red. Gum ducts single, small, usually not conspicuous to the eye, visible only under lens with care ; white deposits not prominent. Rays broad and fine, the latter frequently present in between the broad ones ... *A. scaphula*

1. **A. oblonga** Dyer. Syn. *Shorea nervosa* Kurz—**kaban.**—Well known in Malaya as *mersawa* or *mersawa terbak* ; *kaban, kaban-bok, kabansot* (Burm.). A large, usually deciduous tree with white flowers, 30 to 40 m. or more in height, 3–6 m. in girth, frequently buttressed, with a clear bole of the fissured scaly type similar to some of the species of *Shorea*. In Malay Peninsula it grows in *Schima*-bamboo forests and is often associated with *Shorea talura*. *Bark* yellowish-grey to dull grey-brown, often with gummy exudation ; inner bark laminated, consisting of layers of light and dark brown tissues, thick.

It occurs in semi-evergreen and deciduous forests from Arakan to Mergui, Victoria point (Burma) at low altitudes. Also grows in Malay Peninsula.

Description of the wood—See below.

2. **A. scaphula** Pierre. Syn. *A. glabra* Kurz ; *A. thurifera* Blume, *Vatica scaphula* Dyer, *Scaphula glabra* Parker, *Hopea scaphula* Roxb.—kaunghmu, once well known as mascal wood. *Boilam* (Beng.), *kaunghmu, taungsagaing* (Burm.), *mersawa gajah* (Malaya). A very large tree, 30–46 m. in height, 3–4·5 m. or more in girth, straight bole, often buttressed. *Bark* greyish, with white to greyish-brown patches, peeling off in irregular flakes, fairly smooth, rather thick, about 2 cm. thick. The tree yields a gum but no regular tapping is done.

It occurs in evergreen and semi-evergreen forests up to 600 m. above sea-level, from Chittagong southwards, lower Burma, Thailand to Malay Peninsula.

Description of the wood.—See below.

Description of the wood
(*Anisoptera oblonga* and *A. scaphula*)
(Pl. 15, 86–89)

General properties—Sapwood and heartwood indistinguishable in freshly felled logs but after ageing the sapwood region (5–10 cm.) may be demarcated

from the heartwood zone due to discoloration ; wood pale yellow to brownish-yellow turning brown to occasionally dark pinkish brown or rose-red with age ; soft to moderately hard ; light to moderately heavy (sp. gr. 0·51–0·67 air-dry) ; usually odourless but sometimes have a slight resinous smell in fresh materials ; straight to interlocked-grained ; coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, but occasionally faint growth marks formed by darker coloured fibrous tissue may be seen, which may or may not be annual rings. *Pores* large to small, usually smaller in *A. scaphula*, few to moderately numerous (4–18 per mm^2.), more or less uniformly distributed, occasionally aligned in oblique lines, solitary or in radial multiples of 2–3, round to oval, mostly open but sometimes filled with tyloses ; vessel lines conspicuous. *Soft tissues* distinct only under hand lens, abundant, diffuse to diffuse aggregate forming a sort of network with the rays ; as a rule inconspicuous round the pores but distinct in the zone of tangentially arranged gum ducts. *Rays* broad to fine, the former visible to the eye and the latter visible only under lens, not closely spaced, evenly distributed ; in *A. scaphula*, the broader rays are usually proportionately more than in *A. oblonga* ; radial flecks conspicuous in both. *Gum ducts* small to very small, appear as white specks to the naked eye, distinct under hand lens, fairly numerous and uniformly distributed in *A. oblonga* but fewer and irregularly arranged and often liable to be overlooked in *A. scaphula* ; mostly solitary, occasionally in groups of 2 or more or in long tangential bands filled with whitish deposits ; deposits rather inconspicuous in *A. scaphula* but conspicuous in *A. oblonga*, the ducts easily visible on the longitudinal surface as short or long white lines. *Pith flecks* occasionally present, appearing as small whitish patches.

Strength—*A. scaphula* has been tested for strength. For strength figures see appendix I.

Seasoning—*A. oblonga* is reported to dry very slowly without developing serious defects ; slight warping and surface checking may, however, occur. *A. scaphula* is reported to be a semi-refractory to non-refractory timber ; quick conversion and seasoning is desirable. When fully seasoned the timber is reported to retain its shape well and thus considerably improves its economic value.

Natural durability—Not durable outside, but fairly durable under cover and in contact with water. Graveyard tests at Dehra Dun showed that *A. scaphula* lasts for 22 to 53 months.

Insect and fungus attack—The sapwood of round and converted timber of *A. scaphula* is liable to be attacked by *Heterobostrychus aequalis* Waterh. (Fam. Bostrychidae, Order Coleoptera). Attack by powder-post bettle and dry-wood termites in *A. oblonga* has also been reported. The timber is susceptible to staining and discoloration.

Preservative treatment—*A. oblonga* growing in Malaya is reported to be difficult to treatment. No information is available for *A. scaphula*, but it may not be very difficult to treat with preservatives.

Working qualities—Easy to work and finishes usually to a lustrous smooth surface except when too much twisted-grained. Sometimes presence of silica has a dulling effect on saws.

Supply and uses—Limited supplies are available from Chittagong and Burma. *A. scaphula* is more common than *A. oblonga*. Originally it was used for making canoes by scooping out large trunks and for dug-outs and boat building. It is also suitable for cheap furniture, packing cases, light boxes, cup boards, planking, etc. In Malaya, large buttresses are used for making pans for washing tin. Being a featureless wood, once used to be imported by U.K. for giving different artificial finish.

Material—

A. oblonga – 6675 Burma (0·67), 6885 Burma (0·65), 6884 Burma (0·64), 6886 Burma (0·55).

A. scaphula – 5071 Thaungyin, Burma (0·65), 5100 Toungoo, Burma (0·62), 5839 N. Arakan, Burma (0·61), 6335 Burma (0·62), 6854 Burma (0·62), 6880 Burma (0·52), 6881 Burma (0·52), 6882 Burma (0·53), 6883 Burma (0·60), 6925 Burma (0·52), 6935 Burma (0·51), 6984 Burma (0·61), 7379 Chittagong (0·61).

2. BALANOCARPUS Bedd.

Balanocarpus was originally founded by Beddome on two South Indian trees, *B. utilis* and *B. erosa*, having wingless fruits. Since then about 20 species have been referred to it from the Indo-Malayan region. Recently Symington has removed all the species to *Hopea* and *Shorea* except *B. hemii* King of Malay Peninsula and *B. brevipetialaris* Thw. of Ceylon. Indian species of *B. utilis* has been placed by him under *Hopea* of Euhopea group. On anatomical grounds this change appears to be in order. Very recently Bole has changed *B. utilis* to *Hopea utilis* (Bedd.) Bole Comb. Nov., but has retained *B. erosa* as such due to its so-called similarity to *B. heimii* King. *B. erosa* was, however, not available to us for anatomical study.

B. utilis Bedd. [**Hopea utilis** (Bedd.) Bole]—*karun kongu* (Tam.); some times also known as *black kongu*. A large evergreen tree with straight, clear bole of 18–24 m. and 1·8–4·6 m. in girth. *Bark* of young trees smooth and dark brown in colour, often with greyish patches.

Limited in distribution to the Tinnevelly District of Madras from 300–850 m. elevation, often growing on hill sides close to rivers ; said to grow also in Travancore.

Description of the wood

[Pl. 15, 90 ; Pl. 16, 91]

General properties—Sapwood white to yellowish-white ; heartwood light to dark yellowish-brown, often turning reddish-brown with age ; very hard to extremely hard ; very heavy (sp. gr. 1·00–1·12 air-dry) ; always interlocked-grained, showing as broad bands longitudinally ; fine to very fine-textured with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct to somewhat distinct, delimited either by fine lines of parenchyma or by fibrous tissue with scanty or no pores, 4–8 per cm. *Pores* extremely small, visible only under lens, outlines of pores not always distinct, very numerous, rather unevenly arranged usually in small groups at places, often arranged in short, radial or oblique chains and sometimes in a zig-zag fashion, also solitary, round to oval, filled with tyloses partially or completely ; yellow to orange-brown deposits sometimes present ; vessel lines fine. *Soft tissues* visible only under lens, usually appearing as thin white layer round the vessel groups, also in wing-like projections ; occasionally diffuse, in short fine lines in between the rays, and at places in fine concentric lines at some intervals. *Rays* fine, distinct under lens, closely spaced, orange-brown deposits inside the ray cells often seen on the tangential surface ; inconspicuous ray-flecks on the radial surface noticeable. *Gum ducts* present, but due to very small size not easily discernible, rather irregularly distributed in concentric lines, occasionally may also be present in short tangential lines ; yellowish-white deposits often fill up the ducts and when moistened with water their visibility is assured. *Ripple marks* absent to faintly visible, in some specimens may be locally distinct, 25–30 per cm.

Strength—See appendix I.

Seasoning—Surface cracking quite common, sometimes severe ; may also warp and develop heart shakes. Green conversion and close stacking are recommended for efficient air-seasoning.

Natural durability—Said to be durable.

Insect attack—Malayan timbers are reported to be attacked by pin-hole borers and Curculionid bettles (Foxworthy).

Working qualities—A tough wood, difficult to saw and work with hand. Difficult to plain to a smooth surface due to interlocked fibres.

Supply and uses—Limited supply is available from Kannikatty, Kodamadi and Kudivarai forests of Tinnevelly ; may be available from Travancore forests

also. Used for posts, beams, rafters and planks; as a constructional wood has local importance.

Material—

5169 Tinnevelly, Madras (1·12), 6200 Kodamady (1·04), 7173 Tinnevelly, Madras (1·00), 7225 Tinnevelly, Madras (1·03).

3. DIOTICARPUS Dunn

The genus *Dioticarpus* was established by Dunn to accommodate a single species collected by him from South India. It is said to be very close to *Balanocarpus* but distinguished from the latter by the presence of two winged sepals. Recently Bole, has pointed out that *Dioticarpus barryi* and *Balanocarpus utilis* are synonymous because in both the cases winged and wingless fruits may be developed in the same tree. Based on the similarity of fruits, he has, therefore, combined *Balanocarpus utilis* and *Dioticarpus* under *Hopea* and named these trees as *Hopea utilis* (Bedd.) Bole Comb. Nov. Anatimocal study of the secondary xylem also shows that it is similar to hopeas. It is reported that *D. barryi* sheets in Kew herbarium has been labelled by Hutchinson as "*Hopea*". Parker was of the opinion that *D. barryi* Dunn is a hybrid between *Balanocarpus utilis* and *Hopea parviflora*.

D. barryi Dunn [Hopea utilis (Bedd.) Bole]—Alarge tree about 30 m. high of the evergreen forests of Tinnevelly, Madras.

Description of the wood

[Pl. **16**, 92]

General properties—Sapwood and heartwood fairly distinct. Sapwood grey to yellowish-grey, heartwood brown to reddish-brown sometimes with a yellow cast; moistening the cut end surface and letting it dry makes it dirty yellow like some hopeas; very hard; very heavy (sp. gr. 1·09 air-dry); interlocked-grained; fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct to fairly distinct, delimited by narrow bands of soft tissue or fibrous tissue with scanty pores, about 7 per cm. *Pores* extremely small visible only under lens but even then the outlines not always distinct, very numerous, rather unevenly distributed, usually in small groups which some time join and form an oblique or zig-zag pattern, also solitary, roundish; tyloses often fill up the pore cavity; vessel lines fine. *Soft tissues* (*a*) vasicentric, forming a halo or eyelet sometimes extending sideways either tangentially or obliquely and connecting vessel groups, (*b*) apotracheal parenchyma locally conspicuous as short or long white tangential lines across the rays and also as fine concentric lines, simul-

ating growth marks. *Gum ducts* minute, in concentric lines, very irregularly distributed, sometimes may not be present in wide areas of a disc ; yellowish-white gum often fill up the ducts. *Rays* distinct under lens, rather closely spaced. *Ripple marks* not observed.

Physical and mechanical properties, and uses are very similar to those of Indian *Balanocarpus* and *Hopea*.

Material—

7226 Tinnevelly, Madras (1·09), S. 91.

4. DIPTEROCARPUS Gaertn. f.

The genus *Dipterocarpus* includes about 80 species, which grow mainly in the Indo-Malayan region, having maximum development in Borneo, Malaya Peninsula and Sumatra. The range of its distribution is from South India and Ceylon in the west to Philippines in the east. About 13 species grow in the Indian Zone (Andamans, Burma, Ceylon, India and Pakistan). All are large to very large trees with clear and well shaped boles, and wherever they occur form a potential source of commercial timber. Local names like *gurjun* in India, *in* (*eng*) and *kanyin* in Burma, and *keruing* in the Malay Peninsula have almost become generic equivalents of *Dipterocarpus* woods in the trade ; also sometimes called *penn wood* in Bombay and Karachi markets. Some species may prefer to grow gregariously while others may be widely distributed or locally restricted. According to some observers *Dipterocarpus* species hybridizes freely among themselves and produce natural hybrids. All trees are resinous and yield to some extent an oleo-resin which is sometimes visible on the end surface of freshly-felled trees. Oleo-resin from several species has medicinal properties.

The only fossil record from India is *Dipterocarpoxylon chowdhurii* found in the north-east of Assam between Margherita and Naharkatya and *Dipterocarpoxylon indicum* from the Tertiary of South Arcot, Madras. *Dipterocarpus* fossils have also been reported from Java by Pfeiffer and Van Heurn.

1. **D. alatus** Roxb. Syn. *D. incanus* Roxb., *D. gonopterus* Turcz, *D. lunesbi* Vesque—**gurjun.** *Gurjun* (Andamans, India), *kanyin*, *kanyin-byu*, *kayaing-bataing*, *kyan-wa*, *main-hao* (Burm.), *keruing* (Malaya), *maiyang* (Thailand) ; also known as penn wood. A large to very large evergreen tree up to 46–55 m. high and up to 4·5 m. in girth (maximum record 6·7 m.), with long, clear, cylindrical bole of about 21–30 m. *Bark* greyish, smooth, thin. It is used as a tonic and depurative and also in rheumatism. Essential oil is a resin containing crystalline acid.

It occurs in the evergreen moist forests of South Tipperah, Chittagong, Andamans, Burma, Thailand, Indo-China, Malay Peninsula. It was planted

in the Calcutta Botanical garden in 1809. Trees look very similar to *D. turbinatus* with which it grows in a mixed forest.

Description of the wood—See page 117.

2. **D. baudii** Korth Syn. *D. duperreanus* Pierre, *D. scortichinii* King—**gurjun.** *Kanju, wattaung* (Burm.). A large well-shaped tree, 24–30 m. high and 1·8–2·7 m. in girth. *Bark* pale coloured, smooth.

It is distributed in the evergreen forests of Burma especially Bassein, Insein, Tavoy and Mergui. Also occurs in Sumatra, Thailand, Malay Peninsula, Cambodia and Cochin-China. Sometimes associated with *D. pilosus* trees in the Tenasserim forests, Burma.

Description of the wood—See page 117.

3. **D. bourdillonii** Brandis—**gurjan.** *Charatta angili, karangili* (Mal.), *karanjili* (Tam.). A lofty evergreen tree about 46 m. in height and 1–1·5 m. in diameter, straight boled with light coloured bark. The tree yields resin but no regular tapping is done.

It is distributed in evergreen forests of central and north Travancore at low altitude and also in Malabar.

Description of the wood—See page 117.

4. **D. costatus** Gaertn. Syn. *D. scaber* Buch; *D. insularis* Henei; *D. artocarpifolius* Pierre, *D. parviolius* Heim.—**gurjan.** *Dulia gurjan* (E. Pakistan), *kanhinni* (Burm.), *keruing bukit* (Malaya). A large deciduous tree, 24–32 m. in height and 2–3 m. in girth. *Bark* dark grey, rather rough, flaking off irregularly; inner bark light brownish-yellow. The tree yields resin when blazed or burnt. The resin in said to be used for ulcers.

It occurs from South Tipperah to Lower Burma, Andamans, Thailand, Indo-China and Malaya.

Description of the wood—See page 117.

5. **D. dyeri** Pierre ex De Laness—**gurjan.** *Keruing etoi* (Malaya). A large tree 30–37 m. in height, 2·4–3·7 m. in girth with smooth *bark*. According to Symington, it is a xerophytic Burmese species. In Malaya, it is tapped for oil.

It occurs in Burma, Indo-China, Thailand and Malay Peninsula.

Description of the wood—See page 117.

6. **D. grandiflorus** Blanco. Syn. *D. motleyanus* Hook. f., *D. griffithii* Miq., *D. pterygocalyx* Scheffer—**gurjan.** *Gurjan* (Andamans), *kanyinbyan* (Burm.), *keruing belimbing* (Malaya), also known as long-leaf gurjan. A large to very large tree 30–46 m. high, 2–4 m. or even more in girth. *Bark* light grey to grey, often peeling off in flakes.

Widely distributed from the Andamans and Burma to the Philippines in the evergreen forest up to 600 m. elevation.

Description of the wood—See page 117.

7. **D. indicus** Bedd. Syn. *D. turbinatus* Dyer in part—**gurjan.** Wood oil tree of Malabar. *Kakka, kalapayini, kalpine, kalpayan, vellaini* (Mal.), *yennemara* (Coorg), *aiyini, banasampa, challane, dhuma, ennamara, guyavella, kallone* (Kan.), *ennei, enney* (Tam.). A lofty tree up to 37 m. or more high and 3·7 m. or over in girth; clear bole 18–21 m. cylindrical. *Bark* pale, smooth, deeply cracked, 8 mm. thick. The tree yields sweet smelling oleoresin on tapping and this is said to be used for rheumatism.

It is distributed in the evergreen forests of Western Ghats from North Kanara southwards, Malabar and Travancore. Common in South Kanara at the foot of the hills and at an elevation up to 900 m. especially in South Travancore.

Description of the wood—See page 117.

8. **D. kerrii** King—**gurjan.** *Kanyin ni ,kanyin pyan* (Burm.). In Malay Peninsula called *keruing gondol*. A very large tree 24–37 m. in height and 1·8–3·7 m. in girth. *Bark* dark grey, peeling off in flakes; when tapped yields an oil.

It is distributed in South Andamans, Burma (near Kokypin, Mergui). Also grows in Thailand, Malay Peninsula and the Philippines.

Description of the wood—See page 117.

9. **D. macrocarpus** Vesque.—**hollong.** *Holong, hullung* (Asm.), *kanyin* (Burm.). A very large deciduous tree up to 46 m. in height and 3·7–6 m. in girth; clear bole about 30 m. This was previously confused with *D. pilosus* Roxb. *Bark* light grey to pale bluish-grey towards the outside, reddish-brown inside, turning yellowish near cambium, smooth.

It regenerates well in the forest and natural regeneration has been noticed in 22-year old plantation. It is rather slow growing to start with but grows rapidly afterwards.

It is distributed in Sibsagar, Lakhimpur, Naga hills in Assam; Mergui and Tenasserim in Burma.

Description of the wood—See page 117.

10. **D. obtusifolius** Teysm. ex Miq. Syn. *D. vestitus* Wall. ex Dyer, *D. punctulatus* Pierre—**gurjan.** *In, inbo, kanyingok* (Burm.), *keruing beludud* (Malaya). A medium-sized to fairly large deciduous tree, 6–24 m. high, about 1 to 1·8 m. girth, bole cylindrical and long. *Bark* rough, fissured, thick, very similar to *D. tuberculatus*.

It grows gregariously like *D. tuberculatus* in the lower hill forests of Burma up to 900 m. above sea-level; also in Cochin-China, Thailand and Malay Peninsula.

Description of the wood—See below.

11. **D. pilosus** Roxb. Syn. *D. skinneri* King, *D. augustialatus* Heim—**gurjan.** *Kanyaung, kanyin byan, kanyin ni, red-kanyin* (Burm.), *dhalia garjan, dulia gurjan* (East Pak.), *mao yan deng, red mai yang* (Thailand). A very large tree 46 m. high, and 5 m. in girth with a clear bole up to 24 m.; trees up to 7 m. girth have also been recorded. *Bark* light grey to reddish-grey, appear almost white in young trees, smooth. The tree yields an oleo-resin or balsam which is used in the treatment of diseases of urinary organs.

It is found in East Pakistan, Burma and Thailand.

Description of the wood—See below.

12. **D. tuberculatus** Roxb. Syn. *D. grandifolius* Teysm.; *D. cordatus* Wall.—**gurjan.** *Eng, in, dawngding, kahur, kanklaw-taro, mai-tun, ung* (Burm.). A large tree 30–37 m. high, 3·7–4·6 m. girth. *Bark* dark grey, rough, vertically furrowed, thick. The oleo-resin obtained from this tree is reported to be used along with other ingredients for the treatment of ulcers.

It is distributed in Burma, Cochin-China, Thailand; also reported to be a large tree of Chittagong hill tracts, East Pakistan.

Description of the wood—See below.

13. **D. turbinatus** Gaertn. f. Syn. *D. laevis* Ham., *D. jourdainii* Pierre—**gurjan.** Wood oil tree. *Kherjong, kural sal, tilia gurjan* (Asm.), *kali gurjan, shweta gurjan, telia gurjan* (Beng.), *kanyin, kanyin-ni, kawtho, mai-bao, shinghin* (Burm.). A lofty evergreen tree 37–46 m. high, 4·6 m. girth (90 cm. diameter in Assam). *Bark* light grey, rough, sometimes smooth, vertically fissured, peeling off in irregular flakes. Oleo-resin is applied to ulcers, ringworm, cutaneous affections and the like.

It is a good germinator and up to 85% germination is reported from direct sowings. Being a fast grower, very suitable for plantations.

It is distributed in Andamans, Assam, Burma, East Pakistan, Cochin-China and Thailand.

Description of the wood—See below.

Description of the wood

(*Dipterocarpus alatus, D. baudii, D. bourdillonii, D. costatus, D. dyeri, D. grandiflorus, D. indicus, D. kerrii, D. macrocarpus, D. obtusifolius, D. pilosus, D. tuberculatus*, and *D. turbinatus*).

(Pl. **16**, 93–96; Pl. **17**, 97–102; Pl. **18**, 103–105)

General properties—Sapwood and heartwood fairly well demarcated; sapwood dirty white to greyish to pale yellowish-brown, heartwood pale red to

reddish-brown, sometimes with an orange tinge darkening to red on exposure, occasionally with reddish streaks, often with gummy exudation on the end surface; moderately hard; moderately heavy to heavy, mostly moderately heavy (sp. gr. 0·59–0·91 air-dry); straight to interlocked-grained; coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, occasionally faint marks delimited by narrow bands of thick-walled flattened fibres may be present as in *D. alatus*, *D. baudii*, *D. indicus*, *D. pilosus* and *D. turbinatus*, about 2–3 per cm. *Pores* in most cases moderately large to large, but usually small in *D. indicus* and very large in *D. pilosus*, few to moderately numerous (4–13 per mm.^{2}), uniformly distributed, mostly solitary, a few in radial or oblique pairs, oval to round in shape; open or tyloses fill up the pores partially but sometimes locally occlude the vessels completely; vessel lines usually distinct giving majority of timbers rather a coarse-textured look except *D. indicus*. *Soft tissues* usually visible only under lens, scanty to fairly abundant (*a*) apotracheal parenchyma diffuse to very short or broken fine tangential lines, sometimes visible under lens as white dots within the fibrous tissue; (*b*) paratracheal, round the pores forming a thin layer, usually not conspicuous; (*c*) fairly conspicuous round the gum ducts forming a several seriate layer, occasionally looking like 'eye-let' pattern and often connecting tangential groups of gum-ducts with the rays and pores, usually very well developed in *D. baudii*, *D. costatus*, *D. indicus* and *D. turbinatus*. *Rays* moderately broad to fine, indistinct to distinct to the eye, brownish in colour, not closely spaced, evenly distributed, often showing a conspicuous silver grain effect on the radial surface. *Gum ducts* vertical, present in all species; size rather variable, usually smaller than the pores; small to very small in *D. irdicus*, *D. kerrii*, *D. macrocarpus*, in the rest medium-sized, except *D. pilosus* which in some cases may come up to the size of the pores; fairly uniformly distributed, often solitary in *D. kerrii*, and occasionally in *D. baudii*, *D. pilosus* and *D. turbinatus*, otherwise usually in tangential groups of 2–10 and may be connected with the pores and rays; white deposits sometimes fill up the cavity of the ducts and often can be seen with the naked eye in the end surface and also as white streaks on the longitudinal surface of some resinous specimens; horizontal resin canals not observed in any specimen. *Pith-flecks* occasionally present in some specimens.

Strength—9 species, viz., *D. alatus*, *D. bourdillonii*, *D. costatus*, *D. grandiflorus*, *D. indicus*, *D. kerrii*, *D. macrocarpus*, *D. obtusifolius* and *D. turbinatus* have been tested for strength at Dehra Dun. For strength figures please see appendix I. The Forest Products Research Laboratory, Princes Risborough, England has reported that *D. tuberculatus* in air-dry condition is about 15% heavier, 50% harder and 40% more shock resistant than other *Dipterocarpus* spp. (gurjan). The latter is known to be 40% more in shock resisting ability

and 25% stiffer as compared with teak. In wood bending properties *D. tuberculatus* and *D. obtusifolius* have been classified as moderate. The results are :

For solid bends (steamed)
*R/S (supported) 11
R/S (unsupported) 32

Other *Dipterocarpus* spp. tested at Princes Risborough showed that they easily buckle and are not so suitable for steam bending purposes. The results recorded are :—

Classification ... ... Poor
For solid bends (steamed)
R/S (supported) 30
R/S (unsupported) 60

Sekhar and Rawat have recently recorded torsional properties of *D. bourdillonii* and *D. indicus* under green, air-dry and sometimes kiln-dry condition. For torsion and shear values see *Indian For. Bull.*, 202, 1956. They have also tested nail and screw holding powers of these timbers. The results of which are given below :—

Species	Tests	Composite holding power	Comparative suitability co-efficient Teak : 100
1. *D. bourdillonii* ...	Nail holding power	204	88
	Screw holding power	621	74
2. *D. indicus* ...	Nail holding power	248	107
	Screw holding power	653	78

Narayanamurti and Kaul on their studies on improved wood published in Composite Wood give properties of Laminated wood of *Dipterocarpus macrocarpus* made at 200, 600, 1,000, 1,500, 2,000 lb./sq. inch. Amongst the results published some are of interest such as 20·10 (compression %) ; 0·78 (sp. gr.); 15210 (tensile strength, lb./sq. in.) ; 19872 (modulus of rupture, lb./sq. in.) ; 8760 (compressive strength, lb./sq. in.) ; 9·6 (R.A. impact, ft. lb.).

Seasoning—It is moderately easy to air season. It dries with little degrade. Kiln seasining is difficult and the timber is liable to the formation of moisture

* R is the radius and S is the thickness of the wood. (A handbook of hardwoods published by Department of Scientific and Industrial Research, London. 1956).

pockets as well as to warping and crookedness. Rehman, who has recently made a special study of the seasoning behaviour of *D. indicus*, *D. macrocarpus* and *D. turbinatus*, says that kiln drying is very difficult as they dry very slowly.

Natural durability—Fairly durable to not durable. Of the seven species subjected to graveyard tests at Dehra Dun, *D. indicus* gave the maximum life and *D. kerrii* the minimum. The former lasted for 53–103 months and the latter 25–37 months. The other species gave the following results, *D. alatus* 45–71 months, *D. macrocarpus* 29–46 months, *D. obtusifolius* 38–45 months, *D. pilosus* 29–46 months, *D. tuberculatus* 38–67 months, *D. turbinatus* 29–38 months.

Insect and fungus attack—The sapwood is easily susceptible to insect attack. Information on various species is recorded here in some detail.

D. alatus logs are attacked by *Trochorrhopalus dipterocarpi* Mshll. and *Zeugenia histrionica* Pasc. (Fam. Curculionidae, Order Coleoptera). Record of damage by the former is scanty whereas the damage by the latter is only confined to the surface layer of sapwood which is often removed in the shaping of the log.

D. baudii—Newly felled logs are reported to be liable to attack by shot-hole and pin-hole borers, e.g., *Platypus curtus* Chap. (Fam. Platypodidae, Order Coleoptera), *Webbia 18-spinatus* Samps., *Xyleborus declivigranulatus*, *X. emarginatus* Eich., *X. diversicolor*, *X. nugax*, *X. perparvus* Samps., *X. pseudopilifer* Schedl., *X. siclus* Schell, (Fam. Scolytidae, Order Coleoptera).

D. indicus—Sapwood of converted timber is liable to be attacked by *Heterobostrychus aequalis* Waterh. and *Sinoxylon anale* Les. (Fam. Bostrychidae, order Coleoptera). Sapwood of felled logs is liable to be attacked by *Heterobostrychus aequalis* Waterh., *Sinoxylon anale* Les., and *Xylothrips flavipes* Illig. (Bostrychidae), *Camptorrhinus scrobicollis* Fst. (Fam. Curculionidae); *Atractocerus niger* Strohm. (Fam. Lymexylonidae); *Platypus kanarensis* Beeson, *Platypus obtusipennis* Schedl. and *Diapus furtivus* Samp. (Fam. Platypodidae); *Xyleborus andrewesi* Bldfd., *X. butamali* Bees., *X. granulipennis* Egger., and *X. testaceus* Wlk. (Fam. Scolytidae); *Aeolesthes holosericea* Fabr. (Fam. Cerambycidae, Order Coleoptera).

D. macrocarpus—Sapwood of nearly dry felled logs is liable to be attacked by *Heterobostrychus aequalis* Waterh., *Dinoderus favosus* Les., and *Xylodectes ornatus* Les. (Fam. Bostrychidae). Newly felled logs by *Crossotarsus impariporus* Beeson, *C. saundersi* Chap., *Diapus quinquespinatus* Chap., *Platypus cupulifer* Wich., *P. curtus* Chap., *P. indicus* Strohm., *P. secretus* Samps., and *P. solidus* Walk. (Fam. Platypodidae); *Webbia 26-spinatus* Samps., *W. 30-spinatus* Samps., *Xyleborus fallax* Eich., *X. interjectus* Bldfd., *X. intextus* Bees., *X. resecans* Eggers., *X. schlichi* Stebb. and *X. shoreae* Stebbing (Fam. Scolytidae,

Order Coleoptera). Converted timber is liable to attack by *Heterobostrychus aequalis* Waterh. and *Lyctus brunneus* Steph. (Fam. Bostrychidae including Lyctidae, Order Coleoptera).

D. pilosus—Newly felled logs are liable to be attacked by *Crossotarsus impariporus* Beeson, *C. latelunatus* Beeson, *Diacavus* spp., *Diapus quinquespinatus* Chapl., *Platypus cupulifer* Wich., *P. curtus* Chap., *P. indicus* Strohm., *P. secretus* Samps., *P. solidus*, *P. uncinatus* Blandf. (Fam. Platypodidae); *Xyleborus fallax* Eich., *X. intextus* Bees., *X. shoreae* Stebb. (Fam. Scolytidae). Plywood is attacked by *Minthea rugicollis* Walk. (Fam. Lyctidae) – All Order Coleoptera.

D. tuberculatus—Dry sapwood is liable to be attacked by *Apoleon* (*Dysides*) *edax* Gorh., *Sinoxylon crassum* Les. (Fam. Bostrychidae); *Minthea rugicollis* Walk. (Fam. Lyctidae) and newly felled logs by *Webbia 30-spinatus* Samps. pin-hole borers (Fam. Scolytidae) – Order Coleoptera.

D. turbinatus—Dry sapwood is liable to be attacked by *Apoleon* (*Dysides*) *edax* Gorh., *Heterobostrychus aequalis*, *Minthea rugicollis* Walk. and *Trogoxylon spinifrons* Les. (Fam. Lyctidae) and newly felled logs by *Atractocerus emarginatus* Cast. (Fam. Lymexylonidae) ; *Crossotarsus saundersi* Chap., *Diacavus* sp., *Platypus* (*Platyscaphus*) *Cordiger* Chap., *Platypus curtus* Chap. (Fam. Platypodidae) ; *Webbia 30-spinatus*, *Xyleborus andrewesi* Blandf., *X. bidentatus* Eich., *X. cognatus* Blandfd., *X. exiguus* Walk., *X. incurvus* Eggers, *X. resecans* Eggers., *X. sexspinosus* Motsch., *X. submarginatus* Blandfd. and *X. testaceus* Walk. (shot-hole and pin-hole borers) (Fam. Scolytidae) – Order Coleoptera.

The following wood-rotting fungi are known to cause the decay :—

D. alatus—Attacked by *Fomes albomarginatus* (Lèv.) Cke., causing white pocket rot.

D. macrocarpus—Attacked by *Fomes albomarginatus* (Lèv.) Cke., and *Ganoderma applanatum* (Pers.) Pat.

D. turbinatus—Attacked by *Daedalea flavida* Lèv. causing a white spongy rot ; *Fomes albomarginatus* (Lèv.) Cke. causing a white pocket rot ; *F. lamaoensis* Murr. causing a pocket rot ; *F. lividus* Kalchbr. causing a white fibrous rot ; *F. senex* Nees and Mont., causing a butt rot ; *Ganoderma applanatum* (Pers.) Pat. causing a white spongy rot ; *Polyporus anebus* Berk., causing a white fibrous rot : *Polyporus dichrous* Fr., causing a white rot : *P. gilvus* Schw., causing a pocket rot and *P. rubidus* Berk. causing a white spongy rot.

Preservative treatment—Heartwood slightly refractory to treatment. Of the 4 species tested at Dehra Dun, *D. macrocarpus* was found to be easily treatable. The heartwood of *D. indicus*, *D. tuberculatus* and *D. turbinatus* was found to be treatable but not always with complete penetration of the preservatives.

Working qualities—Easy to work by machine and hand, and can be plained to a fairly smooth surface. It shows a fairly attractive grain when quarter sawn. It is not an ideal turnery timber due to chipping and breaking off on fine edge. *D. bourdillonii* can, however, be turned but not for fine turnery work. Carving can be done though not of high order. It is rather difficult to stain, wax and polish. *D. indicus* can also be turned to a rather rough finish.

Supply and uses—Very large quantities are available from the east zone particularly from Assam (especially hollong, *D. macrocarpus*). From the south zone also, *D. indicus* comes to the market in large quantities. *D. tuberculatus* and *D. turbinatus* are available in large quantities from Burma. It is used for constructional purposes, e.g., beams, scantling, planking, ceiling, floor boards, ship building, masts and spars, dug-outs ; also used for heavy packing cases and for rough furniture. *D. macrocarpus* is being largely used for the manufacture of plywood for tea-chests and it is also suitable for the manufacture of commercial and marine plywoods. The timber can be used as railway sleepers after treatment.

All are good for fuel and some are even considered as excellent. The calorific values of the following woods are given below :—

D. costatus : Sapwood—5,237 calories, 9,430 B.T.U. ; heartwood – 5,284 calories, 9,513 B.T.U.

D. indicus : Sapwood – 5,170 calories, 9,307 B.T.U. ; heartwood – 5,199 calories, 9,358 B.T.U.

D. turbinatus : Sapwood – 5,298 calories, 9,537 B.T.U. ; heartwood – 5,065 calories, 9,118 B.T.U.

Material—

D. alatus – 5919 Tenasserim, Burma (0·82), 5920 Tenasserim, Burma (0·90), 6365 Burma (0·62).

D. baudii – 6426 Burma (0·73), 6624 Burma (0·71), 6895 Burma (0·70), 6896 Burma (0·77), 6897 Burma (0·70), 6898 Burma (0·61).

D. bourdillonii – 5162 Travancore (0·64).

D. costatus – 5921 Tenasserim, Burma (0·82), 5922 Tenasserim, Burma (0·81), 5965 Pegu, Burma (0·78), 6368 Burma (0·85), 6888 Burma (0·87), 6889 Burma (0·81), 6890 Burma (0·97).

D. dyeri – 6590 Burma (0·83), 6891 Burma (0·79), 6892 Burma (0·63).

D. grandiflorus – 5917 Tenasserim, Burma (0·65), 5918 Tenasserim, Burma (0·72), 5976 Tenasserim, Burma (0·85), 6380 Burma (0·75).

D. indicus – 4710 Travancore (0·74), 6219 Tillichery (0·81), 6849 N. Kanara (0·78), 7419 N. Mangalore (0·78).

D. kerrii – 6700 Burma (0·85), 6893 Burma (0·79), 6894 Burma (0·76).

D. laevis – 292 Burma (0·66).

D. macrocarpus – 4700 Dibrugarh, Assam (0·65), 6516 Burma (0·72), 6868 Margherita, Assam (0·73), 7239 Lakhimpur, Assam (0·66), 7393 Sadiya, Assam (0·59), 7526 Sibsagar, Assam (0·69).

D. obtusifolius – 3128 Attaran valley, Burma (0·85), 5160 Burma (0·83), 5915 S. Tenasserim, Burma (0·76), 5916 S. Tenasserim, Burma (0·80), 5964 Pegu, Burma (0·91), 6085 Burma (0·64), 6899 Burma (0·79).

D. pilosus – 6374 Burma (0·69), 6381 Burma (0·72), 6900 Burma (0·70), 7389 Caittagong (0·74), 7136 Burma (0·79), 7670 Chittagong (0·80), 7671 Chittagong (0·76), 7672 Chittagong (0·76), 7673 Chittagong (0·81).

D. tuberculatus – 306 Burma (0·82), 2480 Burma (0·79), 4516 Burma (0·69) 4517 Burma (0·72), 5269 Pegu, Burma (0·80), 5270 Burma (0·90), 5271 Pyinmana, Burma (0·74), 5272 Pegu, Burma (0·87), 5743 Burma (0·85), 6037 Myittha, Burma (0·83), 6038 Myittha, Burma (0·79), 6079 Burma (0·75), 6080 Myittha, Burma (0·78), 6502 Burma (0·78), 7159 Burma (0·78).

D. turbinatus – 293 Burma (0·68), 709 Chittagong (0·79), 2216 Andamans (0·80), 2555 Burma (0·84), 5983 Toungoo, Burma (0·65), 5984 Taungoo, Burma (0·71), 5985 Taungoo, Burma (0·85), 6041 Myittha, Burma (0·88), 6044 Myittha, Burma (0·78), 6081 Myittha, Burma (0·86), 6082 Myittha, Burma (0·88), 6615 Burma (0·62), 7153 Burma (0·81), 7221 Chittagong (0·77), 7242 Sylhet (0·76), 7297 Cachar, Assam (0·83), 7388 Chittagong (0·81), 7605 Cachar, Assam (0·75), 7607 Cachar, Assam (0·75).

5. HOPEA Roxb.

(Excluding *Balanocarpus utilis* and *Dioticarpus barryii*)

Since Brandis's enumeration of the *Dipterocarpaceae* in 1895, no serious attempt has been made to study this genus. However, Symington has lately made a comprehensive study of the Malayan hopeas. In this he has placed most of the *Balanocarpus* under the genus *Hopea*. As a result the genus *Hopea* at present includes about 70 species so far described and a number of them

still remain undescribed. It is widely scattered from India and Ceylon on the west to Philippines and New Guinea in the east. The maximum number of species appears to be concentrated in Malay Peninsula, Borneo, Philippines and India. Its northernmost limit is Assam and China. Indian region has got about 12 species of which 9 were available for this study. Of the other three, *H. andamanica* King is a small to medium-sized tree up to 12 m. high. It grows in the Andaman Islands only. Its timber was not available for study. *H. canerensis* Hole is a medium-sized to large tree, 15–18 m. high and 1·8–2·4 m. girth. It occurs in the hill forests of South Kanara and is reported to be allied to *H. glabra* and *H. racophloea*. The properties of this timber are, however, not known. *H. racophloea* Dyer. Syn. *H. malabarica* Bedd. – **hopea,** *kallu, neduvali kongu* or *veduvali* (Mal.), *karung kongu* (Tam.) is also a moderate-sized to large tree with dark bark, which peels off characteristically in long strips and hang on all round the trunk. It grows in Western Ghats and Travancore up to 900 m. Wood is said to be yellowish-brown or red, extremely hard, very heavy and fine-textured.

The genus is not so important from timber point of view like the shoreas. Moreover, many trees do not attain timber size, while some are only available locally. Indian hopeas are usually small to moderate-sized trees except *H. helferi, H. odorata* and *H. parviflora* which attain 40 m. in height. They grow mostly in evergreen forests, but nowhere in abundance. There is no fossil record from India so far to show that they were growing in areas other than their present distribution.

Gum ducts form characteristic anatomical feature not only of the wood but also of other plant parts. A pale, rather poor colour resin of low value is produced from all trees ; tapping is not resorted to any great extent.

It is not always possible to separate different species in the field due to somewhat similar appearance and structure. Based mostly on hardness, weight and texture, they sometimes may lend to grouping as given below :—

1. Wood usually hard, moderately heavy to heavy, medium to medium-fine-textured. Pores medium-sized to somewhat small, often visible to the eye.

   H. griffithii, H. helferi, H. minutiflora, H. oblongifolia and *H. odorata*.

2. Wood very hard to extremely hard, very heavy and fine-textured. Pores very small, not visible to the eye.

   H. glabra, H. parviflora, H. shingkeng and *H. wightiana*.

1. H. glabra W. & A. Syn. *H. wightiana* var., glabra Bedd.—**hopea**. *Hiribog* (Kan.), *illapongu, irumbakam, naithambagam* (Mal.), *kara kongu, kong* (Tam.). A medium-sized to large tree usually 18–21 m. high, about 1·5 m. girth and clear bole 6 m. long, base of the tree buttressed and stem fluted. *Bark* dark brown to dirty red in colour and flakes off leaving irregular markings.

It grows only in South India in the evergreen forests of South Kanara, Travancore and Tinnevelly up to 1,200 m. altitude, often growing along river banks.

Description of the wood—See page 128.

2. **H. griffithii** Kurz—**hopea.** Known as *merawan jantan* in Malay Peninsula. A glabrous tree of Mergui, Burma; also grows in Malay Peninsula, chiefly on low hills. Outer bark darkish, inner bark reddish to white.

Description of the wood—See page 126.

3. **H. helferi** (Dyer.) Brandis, Syn. *H. dealbata* Hance ; *Vatica helferi* Dyer., *Shorea helferi* Kurz, *Hopea andamanica* King—**hopea.** *Thingan-gyank, thingan kyank* (Burm.), *lintha bukil* (Malaya). A large tree 21–37 m. high, 2–3 m. girth (often 75 cm. diam.), slightly fluted with small buttress. *Bark* darkish or reddish-brown, scaly and flakes off, smooth. The exudation of oleoresin noticeable at the base of the tree.

It grows in semi-evergreen hill forests of the Andaman islands and Burma. Also occurs in Thailand, Cambodia and Malay Peninsula.

Description of the wood—See page 126.

4. **H. minutiflora** Fischer.—A large tree of Tenasserim, Burma.

Description of the wood—See page 126.

5. **H. oblongifolia** Dyer.—A tree 25 m. or more in height. It grows in the evergreen forests of South Tenasserim, Burma and is restricted locally. *Bark* dark grey.

Description of the wood—See page 126.

6. **H. odorata** Roxb., Syn. *H. eglandulosa* Roxb.—**hopea.** Sometimes called white thingan. *Safed thingan* (Andamans), *sauchi, sawkwai, thinsingan, thingan, thingan byu* or *net* or *wa* (Burm.), *chengal pasir* (Malaya). A large evergreen tree 30–40 m., occasionally up to 46 m. high, 2–4·5 m. girth, with cylindrical clear bole, sometimes up to 24 m. *Bark* greyish to dark coloured, scaly with age and longitudinally split. The bark is reported to have high tanin content and is specially suitable for tanning certain types of leather (Symington). Bark is also used in medicine as an astringent. The trees yield 'rock dammar' of the trade. Resin in powdered form is used as styptic.

It grows in the Andaman islands, Burma, Thailand, Indo-China and Malay Peninsula ; also reported to grow in Chittagong, East Pakistan. Cultivated in villages of Malay Peninsula as a shade tree.

Description of the wood—See page 126.

7. **H. parviflora** Bedd.—**hopea.** Also known as Iron wood of Malabar. *Iruppu* (Coorg), *bogimara, borumara, kiralobogi* (Kan.), *kambagom, irumbagam, thambagom, urippu* (Mal.), *kalhoni* (Mar.), *konga, pongu, vellai kongu*

(Tam.). A large, handsome, magnificent evergreen tree 30–37 m. high, and up to a maximum of 4·6 m. girth, with a long, stright cylindrical bole of about 21 m. *Bark* rusty-brown. The tree yields a gum resin.

It grows in evergreen moist forests of Western Ghats, South Kanara southwards up to 1,100 m. altitude ; common in both the moist and dry forests in the Malabar and Travancore up to an elevation of 900 m.

Description of the wood—See page 128.

8. **H. shingkeng** (Dunn) Bor. Syn. *Vatica shinkeng* Dunn—**hopea.** *Shinkeng* (Asm.). A middle-sized tree up to 18 m. tall. *Bark* is greyish-brown, and thick ; it is reported to resemble that of *Vatica lanceaefolia*.

In Assam it grows at an altitude of 160 m. in the lower hills of the Pasighat range. According to Burkill it is a conspicuous tree growing in the Pleistocene gravels at the foot of the Abor hills and on soils over Gondwana and Siwalik strata.

Description of the wood—See page 128.

9. **H. wightiana** Wall.—**hopea.** *Beribogi, haiga, hiral bogi, kalbow, kuri honga, malai haigai* (Kan.), *kalhoni, kaosi* (Mar.), *ilapongu* (Tam.). A small to moderate-sized, fluted and tapering trees, usually attaining 9 m. height and about 1 m. in girth. *Bark* dark, with white patches, exfoliating in old trees, smooth.

It grows in semi-evergreen to deciduous forests of Western Ghats from North to South Kanara, Coorg, Malabar and Travancore up to an altitude of 450 m. It is reported to occur more frequently on river banks.

Description of the wood—See page 128.

Description of the wood

(*Hopea griffithii, H. helferi, H. minutiflora, H. oblongifolia* and *H. odorata*)

(Pl. **18**, 107–108 ; Pl. **19**, 109–111)

General properties—Sapwood pale yellow or greyish-yellow turning pale brown on exposure, heartwood yellowish-brown to brownish-red sometimes with dark streaks ; hard to very hard ; moderately heavy to heavy (sp. gr. 0·62–0·93 air-dry) ; interlocked-grained, occasionally heavily interlocked in *H. minutiflora* and show ribbon-like stripes like *Shorea robusta* ; medium to medium-fine-textured.

Gross structure—Wood diffuse-porous ; occasionally some suggestions of ring-porousness may be found in some specimens of *H. minutiflora* and *H. griffithii*. *Growth rings* indistinct. *Pores* small to medium-sized, varying from just visible to fairly distinct to the eye (usually larger in *H. odorata* and *H. griffithii*), moderately few to moderately numerous (6–14 per mm.^{2}), rather

uniformly distributed, occasionally tangentially aligned as in *H. griffithii*, solitary, or more often in radial multiples of 2–4 or in groups of 3–6, sometimes in oblique chains (*H. oblongifolia*), usually round in *H. helferi*, *H. minutiflora* and *H. oblongifolia* and oval in *H. odorata*, and *H. griffithii*, open or plugged with tyloses ; vessel lines often distinct giving a rather coarser look to *H. odorata* and *H. helferi*. *Soft tissues* visible only under lens, scanty to fairly abundant ; (*a*) apotracheal, diffuse in irregular fine net-like structure (often in *H. odorata*, *H. griffithii* and *H. minutiflora*) ; (*b*) paratracheal, inconspicuous, as thin layers round the pores or pore groups, but sometimes in *H. griffithii*, *H. helferi*, and *H. oblongifolia* forming eye-lets and extending side ways linking the pores but rarely forming concentric or wavy bands ; (*c*) in tangential lines usually associated with bands of gum canals at irregular intervals. *Rays* rather fine, hardly visible to the eye, not closely spaced, evenly distributed, often showing ray flecks on the radial surface ; *Gum ducts* vertical, small to very small usually distinct under lens, often in long tangential lines simulating growth marks, very irregularly distributed ; also in short or broken inturrupted rows ; duct orifices sometimes filled with whitish-yellow deposits and show up conspicuously on the longitudinal surface. *Ripple marks* indistinct to absent.

Physical properties of the timber are available for only *H. odorata* and are given below :—

Strength—See appendix I.

Seasoning—It is a slow drying timber. If stacked under cover, it seasons satisfactorily. It is liable to develop splits along the pith in wide boards.

Natural durability—Heartwood fairly durable, average life of *H. odorata* being 79 months (118 max.–31 min.). It has been reported that as a railway sleeper it lasted for 16–18 years, as dug-outs over 60 years and as sea going boats 25 years. Desch quoting Dr. T. H. Buckley has recorded results of chemical analysis of saw-dust of several hopeas to indicate their comparative durability. Mean figures for alcohol extractives per cent of dry wood of *H. helferi* and *H. odorata* were 7·17 and 20·59 respectively. It is reported that figures in excess of 10% would indicate positive durability.

Insect and fungus attack—Freshly-felled logs of *Hopea odorata* are sometimes attacked by large borers. Though sapwood is susceptible to attack by termites, heartwood remains more or less unaffected. Some hopeas appear durable and naturally resistant even when exposed to insect and fungal attack. *H. odorata* is also reported to be attacked by marine borers like *Teredo napalis*. *H. helferi* is sometimes liable to fungus and powder-post beetle attack. Sapwood of all species is susceptible to sap-stain infection.

Preservative treatment—Heartwood very refractory to treatment ; side and end penetration almost nil.

Working qualities—Sometimes difficult to saw but can be brought to a fairly fine finish without difficulty. Symington reports that sawyers refuse to cut *H. helferi* as the saws get blunt.

Supply and uses—A limited quantity of *H. odorata* is available from the Andaman Islands; large supplies are available from Burma. It is a good durable general purposes timber, suitable for construction, joinery work, boat building, dug-outs, cart and cart-wheels, oil and sugar-cane presses, flooring, furniture, and sleepers. Symington reports that *H. helferi* is much in demand for the construction of ocean going boats. As a flooring wood, *H. odorata* approaches maple to a great extent. As an alternative to maple, this has also been tried with some success for shoe and boot lasts as well as for rollers in the textile industry of Northern Ireland.

Material—

H. griffithii – A 992.

H. helferi – 6692 Burma (0·83), 6902 Burma (0·86), 6903 Burma (0·92), 6904 Burma (0·85).

H. minutiflora – 6666 Burma (0·67), 6852 Burma (0·84), 6905 Burma (0·71), 6972 Burma (0·82).

H. oblongifolia – 6580 Burma (0·99), 6926 Burma (1·15), 6934 Burma (0·95), 6979 Burma (0·85), 6980 Burma (0·70).

H. odorata – 282 Burma (0·62), 511 Andamans (0·78), 546 Burma (0·73), 2201 Andamans (0·81), 2509 Burma (0·68), 2698 Tavoy, Burma (0·79), 2714 Tavoy, Burma (0·77), 2716 Tavoy, Burma (0·80), 5243 Andamans (0·93), 5244 Andamans (0·83), 5245 Andamans (0·91), 5770 Tenasserim, Burma (0·74), 5837 Thanugyin, Burma (0·69), 6444 Burma (0·62), 6931 Burma (0·74), 6933 Burma (0·62), 6936 Burma (0·70), 6937 Burma (0·70), 6971 Burma (0·88), 6973 Burma (0·69), 6974 Burma (0·83).

Description of the wood

(*Hopea glabra, H. parviflora, H. shingkeng* and *H. wightiana*)

(Pl. **18**, 106 ; Pl. **19**, 112–114)

General properties—Sapwood and heartwood not very distinct, wood pale yellow-brown to bright reddish-brown with a yellowish tinge darkening on exposure to deep reddish-brown often with a purplish cast, but sapwood fairly distinct and dirty grey in *H. glabra*; hard to very hard; heavy to very heavy (sp. gr. 0·87–1·11 air-dry), interlocked-grained; fine and even-textured.

Gross structure—Wood diffuse-porous. *Growth rings* indistinct to fairly distinct, delimited usually by narrow bands of fibrous tissue without pores,

sometimes also delimited by tangential lines of soft tissues especially in *H. shingkeng*; concentric bands of gum canals may often be mistaken for true growth rings; about 4 per cm. in *H. glabra*, 3–4 per cm. in *H. parviflora*, 8–9 per cm. in *H. shingkeng* and 4–6 per cm. in *H. wightiana*. *Pores* very small (*H. glabra* and *H. shingkeng*) to moderately small (*H. parviflora* and *H. wightiana*) sometimes medium-sized in *H. parviflora*; numerous in *H. glabra* and *H. shingkeng* (20 per mm.^{2}) and moderately numerous in *H. parviflora* and *H. wightiana* (11–16 per mm.^{2}), uniformly distributed; mostly solitary in *H. shingkeng*, and in the rest solitary to radial multiples of 2–5 or in oblique grouping which may be locally distinct in *H. parviflora* and *H. wightiana*; occasionally tangential alignment of vessels may also be noticeable, usually round in *H. glabra* and *H. shingkeng* to mostly oval in *H. parviflora* and *H. wightiana*; tyloses may partially fill up the pores; vessel lines usually indistinct. *Soft tissues* not conspicuous, usually distinct under lens, (*a*) apotracheal, scattered or diffuse-in-aggregates, seldom profuse except sometimes in *H. parviflora* and *H. wightiana*, (*b*) paratracheal, rather abundant, vasicentric to aliform, usually distinct in *H. shingkeng* and sometimes in *H. glabra* but less conspicuous as a thin layer in *H. parviflora* and *H. wightiana*; inconspicuously confluent in *H. glabra* and *H. parviflora* and rarely in wavy bands which are usually present locally in *H. parviflora* and *H. wightiana*, (*c*) thin concentric tangential lines, initial or terminal parenchyma distinct and regular in *H. shingkeng*, but irregularly distributed in others; short or long tangential lines of soft tissue embedding the gum canals are usually distinct under lens but often so irregularly spaced that these may be overlooked if casually examined. *Rays* moderately broad to fine, scarcely visible to the eye, closely spaced in *H. glabra* and *H. wightiana*, but less so in *H. parviflora* and *H. shingkeng*. *Gum ducts* vertical, small to very small, distinct under lens, often in long tangential lines, very irregularly and widely spaced, whitish-yellow deposits present in the canals, sometimes noticeable on the longitudinal surfaces. *Ripple marks* occasionally present in *H. glabra*.

Strength—Except *H. shingkeng* all have been tested for strength. For strength figures see appendix I. *H. shingkeng* is a very hard and strong timber comparable to the other timbers of this group.

Seasoning—The timber is liable to develop fine surface cracks, and serious splits. It dries slowly and if stacked under cover it dries fairly satisfactorily. Green conversion and piling under reasonable protection is recommended.

Natural durability—Very durable. Two species, viz., *H. glabra* and *H. parviflora* have been subjected to graveyard tests at Dehra Dun. The former lasted for 39 to more than 244 months and the latter 250 to more than 274 months. However, experiments conducted in the South Indian Railways on *H. wightiana* indicate that this species is not very durable in an untreated condition.

Insect and fungus attack—Information available only for *H. parviflora* and *H. wightiana*. Newly felled logs are liable to be attacked by shot-hole borers *Xyleborus* spp. (Fam. Cerambycidae). The unbarked and the fire-scorched poles of *H. parviflora* are prone to the heartwood borer *Massicus venustus* Pascoe (Fam. Cerambycidae) and the sapwood attacked by *Sinoxylon atratum* and *Xylothrips flavipes*. The logs of *H. wightiana* with bark are attacked by *Dihammus griseoplagiatus* Breuning (Fam. Cerambycidae). *H. parviflora* is attacked by the wood rotting fungi such as *Fomes lamaoensis*, *Polystictus tabacinus*, *P. xanthopus* and *Trametes straminea* which cause pocket rot, white spongy rot, white stub rot, etc., *H. wightiana* is susceptible to the wood rotting fungus, *Fomes badius* which causes spongy heart.

Preservative treatment—Heartwood of *H. parviflora* has been found to be very refractory to treatment, side and end penetration being practically nil. The other species are also expected to behave similarly, as can be judged from their structure.

Working qualities—It is rather hard to work and saw. Due to interlocking and curly grain, peeling by rotary method for veneers and plywood is not satisfactory. But once finished it takes a good polish.

Supply and uses—Limited supplies are available from the south zone. It is used mainly as a constructional timber for house and bridge building, piles, ship-building, railway sleepers, rice pounders, platform boards, ladders and engine break blocks. In the Kolar gold fields it is used as beams. Dug-out canoes made out of it last for a very long time. As a fuel, *H. parviflora* is good. The calorific value of the wood is: sapwood – 5,078 calories, 9,141 B.T.U.

Material—

H. glabra – 4671 Travancore (1·05), 6012 Madras (1·09).

H. parviflora – 745 S. Kanara (0·87), 759 S. Kanara (0·92), 4530 Travancore (0·89), 5739 S. Mangalore (0·90), 5932 S. Kanara (0·96), 6332 S. Mangalore (0·93), 6861 S. Kanara (0·87), 7227 Tinnevelly, Madras (0·97).

Hopea shingkeng – 7965 Assam (1·11).

H. wightiana – 5625 Kanara, Bombay (0·94), 5632 S. Kanara (1·02), 5852 S. Kanara (1·11), 6333 S. Mangalore (1·03).

6. PARASHOREA KURZ

Parashorea is a comparatively small genus spreading over a wide area from Burma, Indo-China, Sumatra and Malay Peninsula on the western limit to

Borneo and the Philippines in the east. There are about 12 species, a number of which grow in Borneo. Only one species occurs in Burma.

P. stellata Kurz, Syn. *Shorea stellata* Dyer, *S. cinerea* Fischer—**thingadu.** Also called tavoy wood. *Kabba, kadut, kadutni, kadutpyu, kaunghmu, kawthu, kawwa* (Burm.). A very large evergreen tree up to 46 m. high, with long, cylindrical bole of about 18 m. and 3·7 m. girth. *Bark* rather thick, dark brown, and longitudinally fissured.

It occurs in southern part of Burma in Martaban and Tenasserim and grows up to 450 m. elevation.

Description of the wood

General properties—Sapwood yellowish grey, heartwood yellowish-brown to reddish-brown; somewhat lustrous; moderately hard to hard; moderately heavy to heavy (sp. gr. 0·52–0·93 air-dry), straight to interlocked-grained; even but very coarse-textured; sometimes "ribbon" grain effect like sal, is noticeable on the quarter-sawn surface.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* small to moderately large, fairly distinct to the eye, few to moderately few (4–7 per mm.^{2}), evenly distributed, solitary or in radial pairs, occasionally in oblique chains or in clusters, round to oval, empty to partially filled with tyloses; vessel lines distinct. *Soft tissues* rather abundant (*a*) apotracheal scattered to diffuse-in-aggregates, occasionally running across the rays; (*b*) paratracheal, often conspicuous, vasicentric to aliform, sometimes confluent joining pore or pore groups, (*c*) abundant and distinct round the gum ducts in short or long tangential lines. *Rays* moderately broad to fine, often visible to the eye, spaced widely apart, uniformly distributed, often produce fairly distinct ray-fleck on the radial surface. *Gum ducts* vertical, in tangential bands running for a considerable distance; sometimes also in short rows, and very irregularly distributed; whitish or yellowish gummy deposits frequently fill up the cavity of the ducts and also sometimes visible distinctly on the longitudinal surfaces. *Ripple marks* absent.

Strength—See appendix I.

Seasoning—It dries slowly and is liable to warp and twist. Kiln seasoning is said to enhance the beauty of the planks (Pearson & Brown).

Natural durability—Moderately durable both under cover and in contact with water. It lasts for 60–108 months, average 83 months, in contact with the ground.

Insect and fungus attack—Susceptible to sapstain. Borer attack noticed in the specimens examined.

Preservative treatment—Heartwood very refractory to treatment. Side and end penetration practically nil.

Working qualities—Easy to saw and works well with tools.

Uses—Chiefly used for boat-building in Burma.

Material—

6324 Burma (0·69), 6527 Burma (0·52), 6694 Burma (0·64), 6702 Tharawaddy, Burma (0·80), 6906 Burma (0·67), 6907 Burma (0·65), 6908 Burma (0·67), 6909 Burma (0·64), 6910 Burma (0·79), 6911 Burma (0·88), 6912 Burma (0·77), 6929 Burma (0·79), 6985 Burma (0·93).

7. PENTACME A. DC.

The genus *Pentacme* has three definite species with a very irregular distribution in South-East Asia. Only one species *Pentacme suavis* A. DC. grows in Burma, Indo-China, Thailand and Malay Peninsula, while *P. contorta* (Vidal) Merr. et Rolfe and *P. mindanensis* Foxw. occurs in the Philippines.

P. suavis A. DC. [**P. siamensis** (Miq.) Kurz], Syn. *P. malayana* King., *P. tomentosa* Craib.—**ingyin.** Also known as Burmese sal in India. *Eng-yin, mai-pao, wak, wakbau* (Burm.). Also known as *temak batu* (Malaya) and *mai-pau* (Thailand). A large deciduous tree, 24 m. or more in height and 3 m. or more in girth (Rodger recorded up to 5 m.); trees have cylindrical clear bole and produce fine logs. *Bark* grey to dull brown, sometimes both horizontally and vertically fissured. In Malay Peninsula, it is a small twisted tree.

It grows gregariously usually mixed up with *Shorea obtusa* and *Dipterocarpus tuberculatus* all over Burma but more in North Burma and in Pegu Yomas and in Shan States ; also grows in Indo-China, Thailand and Malay Peninsula.

Description of the wood

General properties—Sapwood and heartwood not clearly differentiated, sapwood dull grey to brown, heartwood brown with yellow cast turning to reddish-brown or dark brown ; very hard ; moderately heavy to very heavy (sp. gr. 0·70–0·98 air-dry), interlocked-grained ; medium coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct, but occasionally visible to the eye due to narrow bands of soft tissues and thick-walled fibres with scanty pores ; concentric lines of gum ducts also occasionally give the impression of growth marks. *Pores* small to medium-sized just visible to fairly distinct to the naked eye, few (4–5 per mm.^{2}), evenly distributed, solitary and in radial multiples of 2–4, occasionally in oblique pairs, round to oval, scanty to heavily tylosed, sometimes filling up the heartwood pores completely ; vessel lines distinct. *Soft tissues* abundant, (*a*) apotracheal, usually scattered, sometimes diffuse-in-aggregate in between the rays, in some samples

may also be present as tangential lines across the rays giving the impression of growth marks; (*b*) paratracheal, inconspicuously vasicentric to distinctly aliform, occasionally extending sideways across a number of rays; (*c*) also as fairly thick bands embedding the gum ducts. *Rays* hardly visible to just visible to the eye, moderately broad to fine, not closely spaced, rather uniformly distributed, and may produce sometimes inconspicuous 'ray-fleck' on the radial surface. *Gum ducts* indistinct to visible to the eye, vertical, in distinct tangential bands arranged at irregular intervals, but often prominent on the end and longitudinal surfaces due to the presence of yellowish-white deposits. *Ripple marks* absent; however, in Malayan samples Desch has recorded irregular storeys.

Strength—See appendix I.

Seasoning—It seasons slowly and develops not many surface cracks like *Shorea robusta* (sal).

Natural durability—A first class durable timber (life over 270 months). According to Pearson and Brown "It requires no treatment when used as railway sleepers, for which purpose it will last 15 years". Rodger recommends that the tree should not be killed by girdling but to be felled green.

Insect and fungus attack—Newly felled logs are liable to be attacked by shot-hole borers. Dry wood is liable to be attacked by the borer *Stromatium barbatum* Fabr. In timber collection, only one specimen was found to be attacked by insects.

Preservative treatment—From anatomical point of view, it is likely to be a difficult timber to treat with preservatives.

Working qualities—A rather difficult timber to work with. It is preferable to saw in green state. It takes a high polish after the surface has been brought to a good finish.

Uses—A good, heavy, constructional timber and suitable for railway sleepers on account of its natural durability. Also used for posts, carts, ploughs, piles, dug-outs, bridge and building construction. It is also used for bows in Burma. According to Rodger, gives good service in mine-shafts, engineering structure and also extensively used in oil-wells in Burma.

Material—

2972 Burma (0·70), 5998 Pegu Yoma, Burma (0·82), 6848 Burma (0·95), 6932 Burma (0·96), 6981 Burma (0·98).

8. SHOREA Roxb.

The generic name *Shorea* owes its origin to sal (*Shorea robusta*), one of the most important forest trees of India. The genus, consisting of a large

number of species some of which occur gregariously like sal, is of great commercial importance throughout the area known as South-East Asia. At present it includes about 103 properly described species but according to Symington there may be as many as 167 species in existence. It is widely distributed starting from Ceylon and India on the west and throughout Burma and other countries of South-East Asia, up to the Philippines on the east. However, the greatest concentration of species is met with in Borneo, Sumatra, and Malay Peninsula, the latter itself accounting for about 56 species. The Indian region has ten species of which only four grow in India proper – one in Assam in the east, one in the north and central parts of India, and two in the south. Symington has grouped shoreas of the Indian region under Balau Group (Section Eushorea) of *Shorea* of Malay Peninsula. Fossil record of the genus is very meagre. Only a few fossil woods from Sumatra and Java have been referred to *Shoreoxylon* by Den Berger and Van Heurn, but Krausel has doubted the advisability of creating this sub-division of the form-genus *Dipterocarpoxylon*. From India, Mukherjee has referred a fossil wood from Sylhet District to *Shoreoxylon* based on its anatomical similarity to the living shoreas. Recently Ramanujam has reported some fossil woods collected by him from South India (near Pondicherry) resembling the woods of the genus *Shorea*. These fossils have been named as *Shoreoxylon holdeni* and *Shoreoxylon mortandranse*.

Apart from the point of view of timber, trees have other economic uses. Seeds contain solid fats, the most important being *Shorea steroptera* Burck of Sunda Islands. The seeds of this tree yield about 40–60% fat which is used in the manufacture of chocolates. Similarly, *S. aptera* Burck from Borneo yields about 50% of solid fat. *S. robusta* also yields sal butter which contain 18–20% fat. This yield is, however, not enough for its exploitation for chocolate making. Seeds of *S. gysbertisiana* Burck yield illipe nuts of commerce and give a fat resembling cocoa-butter in some of its properties.

On tapping trees yield an oleo-resin which is not of great importance like other dipterocarps. Typical dammar is obtained from *S. wiesneri* Schiffn. of Java and Sumatra. Sal (*S. robusta*) also yields dammar commonly known as sal *dhupa*, or lal *dhuna* or *ral*, which is used as an incense in religious functions and sometimes also as a disinfectant fumigator.

Other products reported are tannin and fibres from certain species of shoreas.

Woods of various species of this genus are very similar in anatomical structure. However, in physical properties they vary considerably. Based on weight and hardness it is possible to group them into 3 overlapping classes, viz., soft, hard and very hard. In the first group the lightest of shoreas, *S. assamica* and *S. farinosa* can be placed. These are comparable to the light *meranti* group of shoreas of Malaya. The second group comprises of *S. argentea*,

S. buchananii, *S. gratissima*, *S. sericeiflora* and *S. talura*. Most of these are moderately heavy; only a few are heavy or light. This class more or less corresponds to the *meranti pa'ang* group of Malaya. The last group consists of the well known sal (*S. robusta*), *S. obtusa* and *S. tumbuggaia*. These are the heaviest of the shoreas, although a few samples from outside their natural zones, may be somewhat light in weight.

1. S. argentea Fischer, Syn. *S. obtusa* Wall.—A medium-sized to large tree growing up to 24 m. in height. It grows in South Tenasserim, Burma.

Description of the wood

General properties—Sapwood light brown, heartwood reddish-brown to greyish-brown; hard, heavy (sp. gr. 0·74–0·93 air-dry), interlocked-grained, medium coarse-textured. Sapwood of museum specimens attacked with fungus and pin-hole borers.

Gross structure—See page 155.

Uses—It may be suitable for all purposes for which hard shoreas are used.

2. S. assamica Dyer—makal. *Mekahi*, *mekoi* (Asm.), *kyilan* (Burm.). A large tree, 30 m. or more high and about 3 m. girth, with a long, straight bole. *Bark* light brown to reddish-brown, exfoliating in large raised plates looking like tiles of a roof.

It grows more or less gregariously in Lakhimpur and Naga hills of Assam; also spreads to Burma where it occurs in moist, evergreen forests of Myitkyina and Katha Division. There are other geographical forms of *S. assamica* growing in Malay Peninsula, Sumatra, the Philippines, Celebes and the Moluccas. *S. assamica* Dyer form *globifera* (Ridl.) Sym. is a tree of the Malay Peninsula and Sumatra.

Description of the wood

General properties—Sapwood dirty white to grey, heartwood pale brown to brown, sometimes with a distinct yellow cast when fresh; lustrous; soft to moderately hard; light to moderately heavy (sp. gr. 0·49–0·68 air-dry); fairly straight-grained, but occasionally interlocked in broad bands showing "ribbon" grain effect on board face; texture even, medium-coarse to somewhat fine.

Gross structure—See page 155.

Among the shoreas of the Indo-Burma region, this is relatively a light and soft timber. In this respect, it comes under the "soft shoreas" or "light meranti" group of shoreas of the Malay Peninsula and other islands in South-East Asia.

Strength—See appendix I.

Seasoning—The timber seasons well though liable to some surface cracking. It needs some protection against rapid drying conditions to avoid undue degrading.

Natural durability—Not a durable wood. Graveyard tests at Dehra Dun show that it lasts for 34–71 months.

Insect and fungus attack—Liable to be attacked by several species of powder-post beetle, pin-hole and shot-hole borers. Most important of these are *Aeolesthes holosericea* F. and *Hoplocerambyx spinicornis* Newn. (Fam. Cerambycidae) and some species of Bostrychidae. *Fomes lamaoensis* Murr. and *Ganoderma applanatum* (Pers.) Pat. have been recorded to cause decay.

Preservative treatment—Heartwood is only partially treatable.

Working qualities—Fairly easy wood to saw and work with. It can also be brought to a smooth, lustrous surface without much difficulty.

Supply and uses—In India it is available in fair quantities from Assam. It is mostly used in the form of beams, scantlings and planks for constructional purposes ; also used for furniture, veneers and plywood, tea-boxes, and packing cases.

3. **S. buchanani** Fischer Syn. *S. bracteolata* Dyer—A large tree of evergreen forests of Myitkyina District, Burma.

Description of the wood

General properties—Sapwood greyish-brown, heartwood brown with a yellowish cast ; somewhat lustrous ; wood moderately hard ; moderately heavy (sp. gr. 0·74 air-dry) ; slightly interlocked-grained ; medium coarse-textured.

Gross structure—See page 155.

Uses—It may be used for all purposes for which *S. sericeiflora* is used.

4. **S. farinosa** Fischer, Syn. *S. hypochrae* Hance.—A very large tree of South Tenasserim, Burma, growing to a height of 45 m. In Malay Peninsula this is known as *temak*, *tamak merah*. Also reported to occur in Thailand.

Description of the wood

General properties—Sapwood whitish-grey, heartwood light yellowish-brown to brown ; lustrous ; wood moderately hard ; moderately heavy (sp. gr. 0·48–0·68 air-dry) ; somewhat interlocked-grained ; medium coarse-textured except one sample, which was rather fine-textured.

Gross structure—See page 155.

Uses—The timber is very similar to *S. assamica* and appears to be suitable for all purposes for which *S. assamica* is used.

5. **S. gratissima** Dyer—Known in Malaya as *meranti laut.* A large tree more than 30 m. in height and 3 m. girth, with a good clear bole from 15–21 m.; buttress quite short. *Bark* usually thick, dark brown or greyish-brown, deeply fissured falling off in oblong flakes. Exudation of dammar takes place only in small quantity.

It grows in Mergui, Tenasserim and extends to Thailand, Malay Peninsula and probably also in North Borneo.

Description of the wood

General properties—Sapwood yellowish-grey or brown; heartwood pale yellow brown to reddish-brown; dull; hard; moderately heavy (sp. gr. 0·66–0·74 air-dry); interlocked-grained and coarse-textured.

Gross structure—See page 155.

Uses—Wood very similar to *S. sericeiflora*. For uses see under *S. sericeiflora*.

6. **S. obtusa** Wall.—**thitya.** Some times known as Burma sal. *Mai-bok-phe, mai-ngye, mai-nye, masa, thitya* (Burm.). A large deciduous tree 24–30 m. in height, 2–2·5 m. in girth (sometimes 3 m. and over). *Bark* dark grey with longitudinal fissures, rough.

It occurs sometimes gregariously in Ava, Prome, Martaban to Tenasserim in lower hill forests of Burma up to 600 m. It grows often in association with *Dipterocarpus tuberculatus* and *Pentacme suavis* and is often sold commercially mixed up with the latter under the local trade name "thityaingyin".

Occasionally this is used as a lac producing tree in Burma.

Description of the wood

General properties—Sapwood light grey to brownish-white; heartwood yellowish-brown or reddish-brown; rather dull; very hard; heavy to very heavy (sp. gr. 0·84-1·01 air-dry), interlocked-grained, sometimes showing "ribbon" grain effect like sal, medium-coarse to somewhat fine-textured.

Gross structure—See page 155.

Strength—See appendix I.

Seasoning—A slow-drying wood of refractory nature and prone to surface cracking during seasoning. This defect is not very serious, the cracks being rather fine and straight. However, the end-splitting may be sometimes a serious defect.

Natural durability—One of the Burma woods well-known for durability; very resistant to decay in natural condition. It is also durable, when exposed to alternate wetting and drying and stands very well in contact with water or ground.

Insect attack—Except sapwood, no attack is known; reported to be white ant proof (Rodger).

Preservative treatment—Partially treatable, penetration of preservative is only superficial.

Working qualities—It is a very difficult timber to saw and work with, rather preferable to saw when green. After some difficulty this can be brought to a good smooth surface.

Supply and uses—Supply is always mixed up with *Pentacme suavis*, so separate figure for these is not available. The timber is available in large sizes, squares of 30′ × 12″ × 12″ (9·14 m. × ·3 m. × ·3 m.) are readily available (Pearson and Brown). On account of its natural durability, makes excellent sleepers, bridge timber and for piles and mine props. Its other uses are general construction, carts, plough, rough furniture, boat building, canoes and wells.

7. **S. robusta** Gaertn. f.—**sal**. Widely known as sal in North India. *Hal, sal* (Asm.), *shal* (Beng.), *bolsal, borsal, borsar* (Garo), *sakhu, sakwa, sal, sala* (Hind.), *mulappumarutu* (Mal.), *dieng-blei, rinjal, sarai* (M.P.), *hal-arong* (Mik.), *sakwa* (Nep.), *salwa, sekwa, soringhi* (Or.), *kungiliyam* (Tam.), *gugal, guggilam, saluva, thamba, sarjakamu* (Tel.), *korah, pirjal, serjom* (other names). Also known in ancient literature as *aswakarna*. A large deciduous tree, usually gregarious, growing often to a height of about 37 m. and a girth of 3·7 m. or more, in favourable localities may attain even a height of 46 m. with a clean bole of 18–24 m. and a girth 6–7·5 m.; again, depending upon locality, the tree often grows to 18–30 m. in height and 1·5–2 m. in girth; however, in unfavourable localities it may grow to a height of 9–12 m. only. *Bark* 2·5–5 cm. thick, rough, dark brown with conspicuous vertical furrows. It can be used for tanning or making tan extracts. A brown dye is sometimes extracted from the bark. Locally bast fibres are sometimes used for making ropes. The fibres are short, coarse and reddish in colour and are not of any real value. Bark is used also for fuel purposes.

The tree yields a natural resin (sal dammar) which is frequently burnt in Indian houses as an incense, in religious ceremonies, cremation rites, and for fumigations for warding off mosquitoes at night; also the resin is used for caulking boats and is valuable for paints and varnishes, and as an hardening agent for some waxes. The resin is reported to be used in medicine as an astringent and detergent. It has not proved profitable to tap the trees as the yield is very small; moreover, due to the unscientific method of tapping in vogue a girdled condition is brought about and the trees are ultimately killed. So tapping is not profitable. Tapping carried out in Orissa in 1942–43 indicated that horizontal method gave better results than the vertical. June and September were found to be the best months for tapping. The yield of resin came to about 10·7 tolas per tree. It is said that best quality of resin comes from the first year of tapping.

During the last war there was a great demand for this resin by the Defence Services. In 1943 demand of the Ordnance Department alone was estimated to be about 33,600 maunds of dammar. To meet this sudden demand, tapping experiments were conducted at the Jhajra forests, Dehra Dun, in 1944. One hundred trees of 1·2–1·5 m. girth were tapped according to the method followed in the case of *Balanocarpus* in Malaya. Each tree had six blazes in three rows alternately. In shape, the initial blazes were semi-circular, the size being 10 cm. × 5 cm. with a base of 10 cm. Freshenings were done fortnightly and monthly under two different experiments. The results indicated that June to November was the best period for tapping purposes and the maximum yield could be obtained during September to November. The girth of trees did not seem to influence the yield. The horizontal blazes were found to be better than the vertical ones, while the top-most blazes yielded more gum than those at the basal region of the trees. Furthermore, fortnightly freshenings gave more resin than the monthly. However, these experiments were disappointing, as the yield proved too low for commercial exploitation (see Table III). Moreover, the yield of the resin was very erratic ; some trees did not yield resin at all, others started well but stopped within a short time ; still others yielded only a little even after one year's tapping. Anatomical study of shavings from the blaze (wood and bark) revealed that soon after blazing, formation of tyloses took place in the vessels of the sapwood close to cambial region. This invariably happened in the trees which initially started yielding resin fairly well but stopped altogether later on.

An analysis of the anatomical data indicated that the reactions to wound (blazes) in sal varied from tree to tree. Some trees seemed to resist the wound better than the others, that is, they do not readily produce tyloses blocking the vessels adjacent to the wound as quickly as others do. The formation of tyloses appeared to determine whether the tree was going to be a good yielder or a bad yielder. However, much intensive research has yet to be done before one can find out a suitable method of tapping sal.

During the last war when the import of carnauba wax was restricted, Puntambaker succeeded in preparing a substitute wax for carnauba by using shellac wax as the base for a mixture of bees wax and sal resin. This substitute was found to be satisfactory by the manufacturers of carbon paper who use it. Puntambaker has also recorded the following data on sal resin :—

Specific gravity at 15°C.	= 1·097–1·123
Melting point	= 150°–175°C.
Acid value	= 24·4
Saponification value	= 51·2

Seeds are produced almost every year, but a tendency to have a heavy seed crop once in three years or so is also well-known. Sal seeds are some-

TABLE III.—*Results of experimental tapping of sal for resin in 1944*

Serial No.	Locality	Yield per 50 trees in ozs.								Grand Total	Non-yielders	Yield per 100 blazes for the year in oz.	REMARKS
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.				
	DEHRA DUN												
1	Jhajra forest South plot.	..	4·8	9·9	27·7	83·5	90·4	54·2	13·9	283·6	4	94·5	Open Govt. forest. (Six blazes per tree). Fortnightly freshening.
2	Jhajra forest North plot.	..	..	2·9	3·0	9·0	10·1	24·6	10·9	60·4	8	20·1	Open Govt. forest. (Six blazes per tree). Monthly freshening.
	ORISSA												
3	Panchabhuti ..	..	..	13·6	30·0	42·8	15·6	18·6	8·8	126·4	5	31·6	Closed Govt. forest. Alluvial land. (Eight blazes per tree). Fortnightly freshening.
4	Chandragiri open forest (unreserved) Guimara village.	..	..	0·9	0·7	0·9	0·6	0·9	0·9	5·0	20	1·2	Dry miscellaneous forests. Red earth. (Eight blazes per tree). Fortnightly freshening.
5	Chandragiri Reserve Forest Compt. 5 S.W.C. 9.	..	..	6·2	4·2	4·9	0·9	1·7	0·5	18·4	2	4·6	Rocky. (Eight blazes per tree). Fortnightly freshening.
6	Chandragiri Reserve Forest Guimara Compt. 3, Coupe 8.	..	..	2·6	4·1	3·0	2·5	2·4	0·8	15·1	18	3·8	Rocky, hilly. (Eight blazes per tree). Fortnightly freshening.
7	Chandragiri open Forest Tankalipada Village.	..	..	10·6	6·7	5·1	1·1	1·3	1·2	26·0	4	6·5	Dry forests. Red earth. (Eight blazes per tree). Fortnightly freshening.

(From Forest Research in India and Burma, part I, 1945–46).

times roasted and eaten, especially at the time of food scarcity, e.g., famine of 1897. However, the seeds are not wholesome. It is the cotyledons of the seed which yield an oil, known as sal butter, and is used for cooking and lighting. This butter being white in colour is also sometimes used for adultering *ghee*.

While talking of seeds, the problem of the survival of sal seedlings and the regeneration of some sal forests come to one's mind. This being a very difficult problem it has been tackled from different angles. Some years ago the Wood Anatomy Branch carried out some preliminary investigations on its morphological and anatomical aspects. Some of the main observations of these investigations are recorded here.

To start with, the sal seed is actually a 5-winged, 6–8 ovuled fruit, from which it is not unusual to see development of more than one seedling. Polyembryony also occasionally occurs. Although the seed is very fertile, some time germinating on the tree, yet its viability is very short. It seldom germinates two weeks after its collection. The anatomical investigation of the seed and its growth shows that while the radicle grows fast, the plumules remain for a long time within the cotyledonary sheath. This difference between the development of the root and the shoot is maintained for a long period. Vascularization of the root is much faster than that of the shoot, while in hypocotyl, it is extremely slow. Further, the structure of the hypocotyl is characterized mainly by parenchyma cells, often filled with starch deposits. In the shoot production there is also some provision to meet the unfavourable conditions of growth. Some axillary buds are provided on the axils of the cotyledons. When the main shoot is damaged or starts withering these axillary buds come to the rescue and serve as shoots.

Some experiments were also carried out on sal seedlings grown in water culture with trace elements with a view to finding out whether any of them would stop the dying back of the shoot. These trace elements were zinc, manganese, copper, cobalt and boron. Zinc and manganese were found to have some beneficial effect on the general growth of the seedling but did not give any help in the continuous growth of the shoot. On the other hand, Cobalt had a retarding effect on the general growth. With all these trace elements, the root system was never more than 10 cm. long and there is a tendency to produce considerable lateral root-lets. It is true that the plant fed with trace elements showed a better development of vessels than what is found in natural seedlings. But inspite of all these advantages the seedlings fed with trace elements ultimately died similar to those which grow under natural forest condition.

Sal occurs widely in northern and central India in apparently two zones—one sub-Himalayan region (1,200–1,500 m.) more or less in the north of the Gangetic plain, and the other on the south of the Ganga. In the northern or

sub-Himalayan region it has western limit up to Hoshiarpur in the East Punjab and then extending eastwards through Uttar Pradesh, Bihar, Nepal, West Bengal, East Pakistan and Assam. It reaches its north-estern limit up to Nowgong and north of Balipara in Darrang Division, Assam. Whereas, in the region south of Ganga, its western limit is Balaghat and spreads southwards to Andhra, and then eastwards through Orissa to South West Bengal and south eastern part of Bihar. In short it is one of the outstanding trees of the Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, West Bengal and Assam, besides Nepal.

The distribution of sal in India is of considerable interest because it indicates the north-western limit of the family Dipterocarpaceae. According to some authorities sal was growing during the Muhammadan Period at least near about the city of Lahore. Furthermore, it is believed that heavy pressure on land for agriculture has pushed sal distribution towards east throughout the gangetic plain. It will, therefore, be seen that there has been some radical changes within the last five hundred years or so in the distribution of sal.

Besides, from time immemorial sal has been a landmark in the flora of North India. It's glories are connected with the birth and Parinirvan of the Buddha. Lumbini, Buddha's birth place, which was on the bank of the river Rohini, had sacred sala-groves called "*Mangala-salavana*". It is also said that on the banks of the river Hiranyavati in a sal grove, the Buddha had a bed prepared for himself between two sal trees. Sukraniti while describing the flora of the Himalayan region and upper gangetic plain, classifies sal under the third schedule called *Aranyaka*. Similarly Charaka classifies sal as a common *Aranyaka* species. Kautilya in his *Arthasastra* has put sal among strong timber yielding trees of the forest. In *Ramayana* (Aranyakanda) it is recorded that in Panchabati where Ram built an *asrama* (hermitage), the adjacent hills were covered with *sala* and other trees. In *Ramayana*, the description of the "Asoka-vanika", which was Ravan's pleasure-garden, contained a Sylvan grove with *sala*, *asoka* and other trees.

The quality of sal varies from place to place. This has led to a belief in certain quarters that there are at least two types or varieties of sal. Sal from Nepal, North Bengal and Assam is said to be better than that from other localities. Judging from all points of view it can be said that it is not so much a question of different varieties of trees as the inherent anatomical structure of the sal wood. The fact is that the anatomical structure of sal wood varies to a great extent. In this variation the tissues that mostly take part are the parenchyma cells and the rays. Under certain conditions of growth these tissues develop in a moderate quantity resulting in the production of a wood which is heavy, strong and medium-coarse in texture. While under certain other conditions development of these tissues may be very high. In the latter case the wood becomes rather light, weak and very coarse in texture. It will,

therefore, be seen that it is not the genetical variety so much which is responsible for the quality of sal as it is the condition under which it grows. Experience has shown that the localities said to produce bad variety of sal have also produced the best quality of sal and vice-versa.

While making an intensive study of sal wood, on living trees, Chowdhury has thrown considerable light on the anatomical variation in the formation of its growth rings. He came to the conclusion, after years' of field and laboratory research, that the so-called growth marks in sal are not annual features. They may be formed once or twice a year or may not be formed at all for a number of years. Furthermore, his observations on the relation between the foliar development and the diameter growth has brought forward some fundamental information on the growth behaviour of tropical trees. Though foliar development in sal starts sometimes in April, the diameter growth in the main bole starts 1–3 months later, any time from June to August. This is a very important observation in comparison with the trees of the temperate region where diameter activity usually spreads very quickly in the main trunk, soon after the cambial awakening in the opening buds. In contradiction to the general belief that tropical trees grow in diameter throughout the year, cessation of cambial activity in sal has been recorded by Chowdhury sometime between October and middle of November.

Chowdhury's investigation on the xylem gradient in sal is also of some interest. He re-classified and re-defined the protoxylem, metaxylem and secondary xylum in young shoots of sal and came to the conclusion that it is not so much the hereditary factors which influence the length and width of these tissues as those of the rate of extension growth.

Description of the wood

General properties—Sapwood and heartwood usually distinct ; sapwood when fresh, pale white with a brownish tinge, narrow ; if left unprotected, often turns to almost black colour due to fungus attack. Heartwood light brown to brown turning reddish-brown on exposure ; colour distinction between sapwood and heartwood may not be always uniform, particularly when sapwood is in the process of conversion into heartwood. This transition zone is sometimes called *kucha-pucca* heartwood and apparently looks like heartwood in colour. As this is not true heartwood, this is perishable somewhat like sapwood. The only way to distinguish this *kucha-pucca* heartwood from true heartwood is by the presence of heavy tyloses in heartwood and its absence in sapwood or *kucha-pucca* wood. Wood dull ; hard to very hard ; usually heavy to very heavy (sp. gr. 0·62–1·00 air-dry) ; interlocked-grained, often showing characteristic ribbon bands ; medium to coarse-textured.

Gross structure—See page 155.

Strength—See appendix I. Sekhar and Rawat have studied the torsional properties of sal and recorded torsion and shear values after testing a large number of sal specimens obtained from different states such as Assam, West Bengal, Bihar, U.P.

Seasoning—An extremely difficult timber to season. It dries slowly, develops small surface cracks and is susceptible to case-hardening stresses. Even under mild conditions, planks usually develop numerous surface cracks which may still increase on further drying. Thick scantlings are liable to severe splitting. Slow seasoning under cover in sheltered locations gives the best results. Seasoning in log form followed by conversion and open stacking, may also give better results. Green timber is locally favoured for building purposes. Experiments indicated that sal in small section, dries out more quickly than in logs or large sections. To check case hardening, Rehman and Jai Kishan has recommended steaming at periodic intervals during kiln seasoning for as many as 2–4 hours each time depending upon the intensity of case hardening and thickness of the material.

Interesting results have been obtained by Rehman regarding seasoning of sal for fuel purposes. He has given precise information on the rate of drying and total loss in weight of fuel during storage. Moisture contents of the billets and split woods were 99·6% and 85·8% respectively. It was found that rate of drying was faster in split wood than the billets in the first five weeks but after that both ran parallel. Felled in winter (November) and after stacking for 28 weeks, moisture content of the fuel was reduced to 10–12%, the total loss being 40–50% of the initial weight. Similarly timbers felled in summer had 45–50% m.c. Total loss of moisture in 56 weeks was found to be 24% of the original weight of the fuel. Rehman, while carrying out experiments to indicate seasonal variations of moisture content of Indian woods, found out the equilibrium moisture content of sal in the laboratory to be 96% and 30% R.H., and 95°F. (35°C.) as 20·4 and 5·6, the difference being 14·8%. Based on this Rehman has made several groups and has classified sal under G. III, showing its performance like toon which shows maximum seasonal variations in moisture content.

Natural durability—Natural durability of heartwood is very high as it is not attacked by white ants and fungi for a long time. Graveyard tests at Dehra Dun showed that timber remains in good condition even after 20 years in contact with the ground ; life of 16–18 years is usual for sal sleepers. Sapwood is not at all durable and would require treatment before any use. For example, it is often noticeable that transmission poles, fence posts, and camp pegs are standing *in situ* with all sapwood eaten up. Whatever, little heartwood is there, keeps them still going. Normal durability may also vary depending upon locality factors. Cases are on record to show that even after 22 years, sal was still doing well. Similarly timbers of mature trees after being used for 25 years

were reported to be strong and durable (Narayanamurti – *Indian For. Bull.*, No. 140). Purushottam and Vidya Sagar have reported that proper chemical treatment of sal poles will not only ensure against destruction by insects and fungi but also a life of 25–40 years is possible.

It is believed sometimes that sal from hills and north of the Ganga is more durable than those occurring in south of Ganga. The basis for such a deduction is not known. This much can, however, be said that the heartwood of mature trees, irrespective of their place of origin, is more durable than the immature wood from younger trees. The relative durability is often linked up with the question of *kucha-pucca* heartwood. It is well known that the durability of sal is confined to its true heartwood which is dark brown in colour. The brownish region between the true sap and dark brown heart is not true heartwood and cannot, therefore, be durable. This point is often lost sight of when talking of durability of sal.

Many old records are also available to show the extremely durable nature of sal. For example, the excavation at "Bulandi Bagh" near Patna has revealed wooden drains and other structures to be in a fairly good condition after nearly 2,000 years' use. From this, some have been led to conclude that the people of ancient India had some knowledge regarding preservation of timber. At present there is, however, little justification for drawing such a speculative conclusion. On the other hand there are enough direct evidence that sal timber can last for thousands of years without much deterioration. Plant remains excavated by the archaeologist from Pataliputra show, that sal was used for the wooden palisade made in that city 2,300 years ago. Wooden beams excavated from the "Mauryan Pillard Hall" of the same city indicate other important uses of sal known to the people of the Budhist Period. Another example of durability of sal was from Sambalpur, Orissa, where it was embedded in a tank about a thousand year back and was still found to be all intact. To quote a more recent record, the gateway of historic Delhi Fort was found to be made of sal. When we examined these ancient woods, one point impressed us most was that the timber used was not of average quality that we come across nowadays. In all cases the anatomical structure of these timbers showed that these were specially selected because they were the best quality wood that sal can produce.

Insect and fungus attack—One of the principal defoliators of sal is *Lymantria mathura* in Assam and North India. In Bengal severe defoliation is caused by *Maurilia iconica*. Freshly felled trees are not normally attacked during the first month but it starts from second month onwards. It has been observed that heavy attack occurs if logs are stored in the sun. This indicates that some drying accelerates insect attack ; borer beetles have caused havoc in sal trees especially in Uttar Pradesh and Madhya Pradesh by killing healthy trees. It is reported that profuse exudation of resin (sal dammar) may sometimes

be a symptom of borer attack (*Hoplocerambyx spinicornis*). Both sapwood and heartwood are attacked by insects. *Xylothrips flavipes* and *Xylodectes ornatus* (Family – Bostrychidae) usually attack sapwood. Major damage to both sapwood and heartwood is done by the borers of the family Cerambycidae (*Hoplocerambyx spinicornis* and *Acolesthes holosericea*). Among other borers which cause damage to both sap and heartwood belong to Cerambycidae, Curculionidae, Anthribidae, Eucnemidae, Scolytidae, Platypodidae and others. Sebastian reports that it is subjected to the action of marine boring organisms. Bark is damaged by insects of the families Termitidae, Arbelidae and Coccidae.

Bhatia, who studied extensively the borers of sal poles in Orissa and Uttar Pradesh forests during 1946–48, found out that the principal borers causing damage to sal ballies are : (1) powder post beetles or ghoon (Bostrychidae), (2) sap and heart-borers or ambrosia beetles (Platypodidae and Scolytidae). Based on this study he has recommended certain control measures for the prevention of borer attack. [For details see *Indian For. Rec.* (Entom.), 8, 4, 1950].

It has been estimated that about 150 species of fungi cause damage to sal trees and timber. Many types of rot belonging to several genera such as *Fomes*, *Ganoderma*, *Lentinus*, *Lenzites*, *Polyporus*, *Polystictus*, *Trametes*, etc., have been reported. During the last war millions of sal poles or ballies were damaged due to the incidence of fungus attack. The most important of these were identified as *Fomes lividus*, *F. lignosus*, *Polystictus steinheilianus*, *Lentinus subnudus*, *Tremates cubensis*, *Stereum hirsutum* and *Polyporus ostreoformis*.

Most of the common decays of heartwood of sal used in service can be traced to living trees which become infected by the fungi during various stages of growth of the trees. Important fungi which cause unsoundness in sal over its entire range of distribution in India are *Fomes carryophylli* (popularly termed 'gauj') and *Hymenochaete rubiginosa*. Though trees of all age classes are liable to infection, young pole crop is most susceptible. Fire, frost and suppression working individually or collectively are the factors which predispose sal to attack by 'gauj' while with *H. rubiginosa*, fire is the principal contributory factor. Both these fungi cause unsoundness in heartwood and continue to work into sound wood with increasing years. The affected trees continue to grow enclosing the unsound timber within it. The affected trees exhibit various symptoms by means of which the disease can be identified. For a detailed pathological and mycological account of the fungi on sal, readers are referred to papers by Bagchee and Bakshi.

On conversion of the logs of the infected trees, the fungi do not die and may remain viable for many years, so that more and more of sound timber is decayed. Many of the fungi are known to cause decay of heartwood of sal (Bagchee), few of which establish *de novo* in the wood while majority can be traced as a heritage

from the tree while standing. These fungi fall into two groups depending on the nature of decay. In the one, lignin is mostly destroyed so that a 'white rot' is produced, which may be 'spongy' or disposed in form of 'pockets' in the decayed wood as in 'gauj'. In the other, cellulose is mainly destroyed and a 'brown rot' is produced. The latter is more severe than the former. In both, the affected timber looses considerably the strength properties and cannot therefore, be put to any useful purpose. A high percentage of rejection of sal sleepers for railways is attributed to the decay caused by the wood destroying fungi.

Preservative treatment—Sapwood is easy to treat with all preservatives. Heartwood is very refractory to treatment ; side and end penetration is practically nil. The difficulty faced with the treatment is due to mainly heavy tyloses formation in the pores or vessels. Sometimes all the pores of heartwood are completely blocked with tyloses. Young sal poles, due to their straightness and length, are in great demand for electrical transmission lines and these are generally successfully treated due to the presence of extensive sapwood in the pole stage. Poles when treated with open tank process show complete penetration but with Lowry Process only mottled penetration is obtained. Treatment of poles is easy as compared with rectangular sleepers because in a pole there is always good proportion of sapwood all round for easy treatment.

Working qualities—A difficult timber to saw and work with due to heavy interlocking of fibres. Less difficulties are experienced when sawn green than when dry. While working with machines, picking up of fibres often takes place and it is difficult to get a smooth surface. A medium gauge of saw gives good result and for machining, cutters should not be ground too fine.

Due to interlocking of fibres, a "ribbon" grain effect is produced which is very characteristic for sal. This figure is best seen on the face of a quarter sawn sal board and is the result of spiral reversal that occurs in this tree every few years. The width of alternating bands of light and dark colour may, however, vary to some extent producing beautiful figure. On closer examination of these bands, it may be observed that one band is more or less parallel, and the next one oblique to the axis of the log. The result of this is that splitting of wood is extremely difficult – more in the radial than in the tangential direction.

Supply and uses—Being a gregarious tree that grows over a large area of the Indian sub-continent, sal forms the largest bulk supply of timber in North India. The timber is used in the form of logs, railway sleepers, beams, poles, ballies, scantlings and off-cuts. Although the exact volume that is available in the country is not known, yet there is little doubt that the quantity consumed is considerable. During the World War II some estimates were made as to its availability. At first the out-turn was estimated to be about 8 million

cubic feet (227,000 cu. m.) from all sources. This later rose up to 10 million cubic feet (283,000 cu. m.). The highest quantity of supply was reached in 1944 when 100 million cubic-foot or 2 million tons were obtained. Of this quantity one-third was formed of sleepers and the rest for other war purposes.

For the second five-year plan it has been estimated that a supply of at least 10 million sleepers per year will be required for railways, industries and forest department. On checking it has been found out that a supply up to 12 million sleepers will be forthcoming for these purposes. In this connection the figures supplied by some states are available and given below in a table.

TABLE IV.—*Availability of sal sleepers in some states*

I.S.I Zone	States	Number of sleepers			
		B.G.	M.G.	N.G.	½ round M.G.
North	*Himachal Pradesh*	30,000	12,000	..	13,000
	Uttar Pradesh	75,000	2,55,000	1,10,000	1,30,000
East	*West Bengal*				
	(*a*) Kurseong Division ..	28,740	28,046	24,800	13,350
	(*b*) Kalimpong Division ..	..	7,000	7,000	..
	(*c*) Jalpaiguri Division ..	15,000	30,000	..	..
	(*d*) Buxa Division ..	30,000	20,000	10,000	..
	Assam				
	(*a*) Garo Hill Division ..	4,000	6,000	..	..

In addition to above, the out-turn expected from Nepal is about 4 lakhs sleeper per year.

Besides sleepers, sal is in great demand in the form of ballies and poles. During the last world war demand for poles rose to a very high pitch. It is reported that during the years of war, 2½ million poles were annually supplied. Sal poles after preservative treatment have been found to be suitable for overhead electric transmission and distribution lines, telegraph and telephone circuits. For the specification of these poles sal has been classified under group "A", after test by the Forest Research Institute. Group "A" includes those strong timbers which have a modulus of rapture in bending of clear specimens ranging between 850–1050 kg. per sq. cm. On the availability of sal for transmission poles, some data are available and these are given in Table V.

The best supplies of sal are from Uttar Pradesh (Kheri, Bahraich, Gorakhpur, Ramnagar, Haldwani and Dehra Dun Divisions as well as Lansdown, Gonda and Pilibhit), from West Bengal (Kurseong, Kalimpong, Jalpaiguri,

Buxa Divisions) from Assam (Goalpara, Kamrup, Mechpara Estate) ; Other important sal yielding areas are Bihar (Singhbhum), Orissa (Sambalpur, Angul, Mayurbhanj, Bonai, Bamra, Rairakhol and Keonjhar). Another rich source of sal supply is Nepal.

TABLE V.—*Availability of sal poles in different states*

State	Sizes of poles	Quantity available per annum
Bihar	30′ (9 m.) over all length	8,000
Orissa	35″ and 36″ (89 and 91 cm.) girth at butt.	27,000
Punjab	20′ (6 m.) in length	4–5,000
West Bengal ...	30′ (9 m.) in length	3,000

Sal continues to be one of the most coveted, untreated timber for all types of constructional work where strength and durability are the main criteria. It has many uses. The most important uses are for sleepers, beams, scantlings, rafters, floors, piles, bridges, carriage and wagon building, dug-out boats, ladder, carts, spokes, fallows, hubs of wheel, tool handles, picker arms, tent pegs, ploughs, dyeing vats, beer and oil casks. Recently Chowdhury has recommended sal to the ship building industry in place of imported douglas fir which is at present used for shifting boards and feeders for grain loading. Based on this recommendation a large quantity of sal will be required annually for this single industry alone. Sal is very good for fuel. The calorific value of the wood is ; Sapwood – 5,095 calories, 9,173 B.T.U. ; heartwood – 5,433 calories, 9,779 B.T.U. However, some people do not like it because of the sparks that it sometimes gives due to the presence of gum ducts.

Sal bark once formed a useful vegetable tanning material along with leaves, twigs and branches. The bark from old trees is not as rich in tannin as of the younger trees. This is due to the fact that in old bark there is considerable periderm tissue deficient in tannin. The tannin content is given here – (*a*) bark, 9·2% tannin ; (*b*) old leaves, 7·0% tannin ; (*c*) young leaves, 20·0% tannin ; twigs and leaves, 22·0% ; powder dust, 12·0% tannin.

After extraction of tannin, the by-product has been found to yield 45% cellulose. The length of these fibres vary from 1·0 mm.–1·55 mm. and might be used for making wrapping paper and boards.

As a fuel, sal bark is also used in many localities where it is available in considerable quantities. The output of the bark is considered to be from 13% to 34% of the log. In small logs of about 30–45 cm. in girth, the bark is 38%, whereas in larger logs of about 2·7–3 m. in girth, it is about 13%.

Some preliminary experiments conducted by Narayanamurti and Das indicated that there is a possibility of utilizing sal bark in admixture with saw-dust and resin for the production of boards. Narayanamurti and Harcharan Singh have tried sal bark as fillers in phenolic plastics at 150°C. or 200°C. to replace wood flour with good result. The same authors have tried making building boards from tanniniferous sal bark wastes. It has also been reported that not only boards of good strength can be obtained from sal bark but the strength properties can be improved by addition of saw-dust. They have also recorded interesting data on different aspects of analysis of sal bark with the object of producing boards of suitable properties (details in Composite Wood **2**, 3, 1955). Further Narayanamurti and George have made some studies on the production of boards and plastics from fungus infected saw-dust. Sal wood used in their study was attacked by *Hexagonia sulcata* and *Trametes cubensis*. The moulded products obtained from such wood were found to have desirable strength and water resistance properties. They have also given data regarding chemical composition of fungus attacked sal wood.

From the many uses of sal given above one may be led to think that these wonderful qualities of sal tree and its products have been brought to light entirely by modern science. But this is not the case. Old literature of ancient India repeatedly mention sal wood and its wonderful qualities. *Brhatsamhita* declares sal wood as auspicious (*subha*) and recommends its use for beds, seats, etc. ; *Yuktikalpataru* giving the timbers to be used for the construction of different types of thrones recommends sal for *hamsa-simhasana*. Again, *Kabikankan candi* mentions sal as one of the most suitable timbers for the construction of ships in ancient Bengal along with teak (*Tectona grandis*), *gamari* (*Gmelina arborea*) and *kathal* (*Artocarpus integrifolia*). There are many other such references in literature.

Recently some direct evidences on the uses of sal in olden times have come to light as a result of anatomical investigation carried out on the plant remains excavated from the sites of ancient civilization by archaeologists. It is now known that about 2,000 years ago, sal wood was used in the performance of *yagna* in connection with the horse-sacrifice ceremony (*Ashwamedh*) at a place, called Jagatgram near Kalsi, 32 miles from Dehra Dun. Incidently, this is the earliest record of horse-sacrifice ceremony in India. Again, sal charcoal was recovered from the excavation at Ahichchatra, capital of North Panchalas. The site is known to be about 1,000 years old. The other uses of sal timber and the light they throw on the knowledge and experience of people of ancient India, have been dealt with under natural durability, etc.

8. **S. sericeiflora** Fischer et Hutch. Syn. *S. floribunda* Kurz, *S. gratissima* of Foxw. in part—*kabanthangyin, kaban-ywetthe, thingan-byu, thingan-wa* (Burm.). In Malaya Peninsula it is included under the meranti Pa'ang

group of *Shorea* and locally called *meranti jerit*. In Burma, it is a large tree up to 30 m. high and 2 m. in girth with a clear cylindrical bole of about 14 m. *Bark* dark grey to brown, rather rough with longitudinal furrows. In Malaya a dammar of brown to yellow in colour, is obtained from this tree.

It grows in the evergreen forests of Tenasserim, Lower Burma, Thailand and Malaya, especially Langkawi Island where it is a common tree in the hill area.

Description of the wood

General properties—Sapwood fairly distinct, white or grey to light yellow, turning sometimes to a brownish-grey shade, about 5 to 7·5 cm. Heartwood yellowish-brown with pinkish tinge at places turning to a deeper shade of brown or pink colour ; slightly resinous ; somewhat lustrous ; hard, moderately heavy to heavy (sp. gr. 0·73–0·79 air-dry), usually interlocked-grained ; medium-coarse and even-textured.

Gross structure—See page 155.

Strength—Not yet tested. Desch gives average weight 57 lb. (55·2–61·5 lb.) per cu. ft. at 15% moisture content. The Malayan species appears to be harder and heavier than the specimens we have examined.

Seasoning—According to Desch, the board would require careful drying to avoid cupping and warping.

Natural durability—It is evident from the local name that it is a durable timber. In the Bassein district of Burma, it is considered equal to that of *Hopea odorata*. In Malaya where this timber is also available, Desch considers it probably more durable than the timbers of *meranti pa'ang* group tested there, i.e., *S. bracteolata* and *S. hypochra*. Further, he says that from the point of view of density, *S. sericeiflora* has similarity with the lighter forms of balau timbers which belong to medium to heavy, durable, constructional timbers of the Peninsula. Moreover, he observes that timbers of *meranti pa'ang* group, including *S. sericeiflora*, are likely to be resistant to marine borers due to high silica content.

Insect and fungus attack—None of the specimens in the Forest Research Institute, Dehra Dun, collection has so far been attacked either by fungus or insect. Desch reports the same experience in the Kepong wood collection (Malaya) and remarks that the timbers of the *meranti pa'ang* group (including *S. sericeiflora*) would appear to be less liable to borer attack than other groups of *Shorea*. According to him, after felling 'pin-hole' borers attack sapwood readily. It is also not entirely free from the formation of "spongy heart" and in the case of old trees, the centre may occasionally be hollow. Sapwood is reported to be susceptible to blue stain unless proper ventilation is provided at the time of drying (Desch).

Preservative treatment—Not tested so far but Desch reports that "impregnation of timbers in the '*meranti pa'ang*' group involves the use of drastic schedule to secure even small absorptions of preservatives". This indicates that treatment of *S. sericeiflora* with preservatives may give some difficulty.

Working qualities—Actual information based on trials is not available. According to Desch it would appear to give trouble in sawing and might produce woolly surface on planing. The sawing difficulty is traceable to abundant silica deposits in ray cells and this might be overcome by using either best quality steel saws or with widely spaced teeth and thicker gauge. It is reported that this sawing difficulty can actually be solved if the teeth of the saws are tipped with tungsten carbide. However, the specimens cut and planed for the Dehra Dun collection indicate a fairly smooth surface though there may be some 'picking up' in quarter-sawn pieces.

Supply and uses—A limited supply is available from Burma. The timber is of local value. Though somewhat harder and heavier than *Shorea assamica* with which it has also some similarity in structure, it can be used for most purposes for which *S. assamica* is used. The Malayan species, which is harder and heavier, is reported by Symington to be used for the construction of "tongkangs, an ocean going, Chinese sailing ship".

9. **S. talura** Roxb. Syn. *S. laccifera* Heyne, *S. floribunda* Wall. ex Kurz, *S. cochinchinensis* Pierre, *Vatica laccifera* Wight—Lac tree of South India. *Jala* (Coorg), *jal, jalada, jalaranda, jalerimaran, jali, jhallmara* (Kan.), *jhallanda* (Mysore), *kungili, kungiliam, pinna-marom, talari, talura* (Tam.), *jalari* (Tel.). In Malaya called *temak*. A moderate-sized to large tree up to 27 m. high, and 2·4 to 3 m. in girth. *Bark* light-grey, fleshy, smooth or narrowly fissured, about 20 mm. thick.

Trees yield a resin (dammar) which is not of any importance. However, the trees are of great value as a good host of lac insect in South India. The trees yield a moderately good lac crop when inocculated with Deverbettakusum lac insect (*Laccifer lacca*) in monsoon season.

In India, it grows only in the moist deciduous or evergreen forests of the west coast, Kanara forests in the Bombay State, Coorg, Madras, Malabar and Mysore, up to 900 m. elevation. It is not typically gregarious but usually occurs in patches in damp valleys, near streams and hill slopes. Some of its important associates are *Dalbergia latifolia, Mangifera indica, Mimusops* sp., *Phoenix, Pterocarpus marsupium, P. santalinus*, and terminalias. In Madras State it grows in Pikkilikone valley, Tummalabilu, Seshachellam hills, South Cuddapah. In North Salem it occurs in small patches and is scattered in the Hosur plateau but at some places there may be a tendency to grow gregariously. These patches rarely exceed 200 hectares in extent. The most important of these is to be found in the Thali, Javalagiri, Tholavubetta reserves as well as

in Aiyur, Denkani Kola, Pane, Hulibanda and other reserves. The trees here are usually stunted and the boles are badly shaped. In Jalakona plateau it is scanty, grows with *Eugenia alternifolia*. These trees are rather stunted and crooked in shape.

It is now reported that this South Indian species grows also in Burma, Indo-China and the Malaya and Thailand. The Burmese species *S. floribunda* Wall. ex Kurz, *S. cochinchinensis* Pierre of Indo-China and the Malayan species *S. talura* are all considered by Symington as same or a form of South Indian *S. talura*. In Thailand, it sometimes grows with teak in dry mixed forests. In Malay Peninsula it is said to be gregarious in certain parts or occur as a more common tree of 'Schima-bamboo' forest. Here the trees are small to large with small buttress but in exposed conditions the bole becomes badly shaped. Sometimes it is also cultivated.

Recently Rao has worked out the embryology of *S. talura* for the first time. Unlike sal, its seeds retain viability throughout the fruiting season.

Description of the wood

General properties—Sapwood light yellow to yellowish-brown or grey. Heartwood light yellow-brown, turning to reddish-brown or dull red on exposure ; hard ; moderately heavy to heavy (sp. gr. 0·73–0·79 air-dry) ; straight to interlocked-grained ; even and medium coarse-textured.

Gross structure—See page 155.

Strength—A moderately strong timber. Pearson and Brown quoting Kann give the following strength figures :—

TRANSVERSE STRENGTH IN LB. PER SQ. INCH		Crushing parallel to grain in lb. per sq. inch
Breaking strength	Modulus of elasticity or young's modulus	
11,400	1,590,000	8,065

Seasoning—It is not a refractory timber and should season without much difficulty. According to the tests carried out in Malaya of some timbers of *meranti pa'ang* group which includes *S. talura*, it is indicated that radial tangential shrinkage would be over 4% and 8% respectively from green to oven-dry condition of such timbers. Moreover, to prevent cupping and warping, board thicknesses require care in drying (Desch).

Natural durability—Not durable. Graveyard test at Dehra Dun, showed that it lasts for 55–62 months. It is reported to be durable when used for mining purposes.

Insect attack—Beetle attack following fire has killed a large number of trees in North Coimbatore.

Preservative treatment—Heartwood very refractory to treatment; side and end penetration practically nil.

Working qualities—Somewhat difficult to saw; on planing works to a hard, smooth surface. Experience of sawyers of Malaya indicates difficulty in sawing due to high silica content in these timbers and the sawn surfaces may show woolliness.

Supply and uses—Due to scattered trees, supplies are small but moderate supplies may be obtained from Madras. It is locally used in constructional work such as beams, trusses, struts for trusses, bridges, pentoons, piles; also used for cart shafts, ploughs, canoes, boat building, wells, tool handles, rough furniture and sleepers. Troup reports its use for "timbering" in Kolar Gold Fields. It is excellent for fuel. The calorific value of the wood is: Sapwood – 5,247 calories, 9,445 B.t.u.; heartwood – 5,610 calories, 10,100 B.t.u.

10. **S. tumbuggaia** Roxb. Syn. *Vatica tumbuggaia* W. & A.—*tembagam, tampakam, thambagum, vanbogar* (Mal.), *cangu, congo, karunthumbi, karuppudamar, tambagum, tambugai* (Tam.), *googgilapa-karra, jalori, nalladammara, tamba, thamba* (Tel.). A medium-sized tree with a clear bole of about 3·7 m. in length and about 1 m. in girth. According to Troup, larger trees of about 18 m. in height and about 2 m. in girth have mostly been cut and such trees are therefore, now rare. *Bark* dark, thick, rough with longitudinal fissures resembling sal to a great extent. The tree yields a dammar which is locally used sometimes in place of pitch and also as an incense. Resin is sometimes used in medicine as external stimulant.

It grows only in Madras State and distribution is also limited in certain areas such as in the Seshachellam and Palkonda hills (Cuddapah and North Arcot Districts), up to 900 m. elevation. Though not exactly gregarious, the tree sometimes occurs plentifully in small to large patches and in this respect as well as in general appearance resemble *Shorea robusta* of North India. Its important associates are *Pterocarpus santalinus, P. marsupium, Anogeissus latifolia, Chloroxylon swietenia, Terminalia tomentosa, Dalbergia latifolia* and others. According to Cox, Conservator of Forests, *S. tumbuggaia* in the past was more widely spread than at present. He further observed that it is capable of growing to a very large size up to 4 m. in girth or so as indicated by the older stumps but at present trees of even 1·3 m. girth is rather rare. Usually trees from 1–1·5 m. in girth are now commonly distributed over a wide area in Seshachellam and Palkonda forest, Cuddapah District, Madras.

Description of the wood

General properties—Sapwood lighter in colour than the heartwood, often light grey-brown, sometimes with pale yellow cast; heartwood brown to

reddish-brown and quickly turning dark brown or red on exposure ; rather dull ; very hard ; very heavy (sp. gr. 0·97–1·08 air-dry) ; somewhat straight to interlocked-grained, occasionally showing ribbon-like bands ; medium to nearly fine-textured ; rather close and even-grained.

Gross structure—See below.

Strength—Not tested yet. As quoted by Gamble, Baker gives P = 902 to 996, and Skinner, P = 980, indicating that it is a hard and strong timber.

Seasoning—According to Pearson and Brown, it is difficult to season and is liable to warp and crack.

Natural durability—Not tested. It is, however, reported to be a durable timber and so there is a demand for it in Cuddapah District, Madras. Troup says that it stands well under water and, therefore, there is a demand for its use in well-linings.

Insect attack—Pearson and Brown record that it is immune to insect attack. Very old specimens in the Dehra Dun collection also do not show any attack with the exception of one specimen in which case the sapwood is badly attacked by borers. It has, however, been recorded by the Forest Entomologist that the trees are attacked by borers, probably by *Hoplocerambyx spinicornis* of *Cerambycidae* family.

Working qualities—Easier to saw in dry than in green condition. It works well and can be brought to a smooth finish with a little care. Heavily interlocked-grained specimens will offer difficulty in planing.

Supply and uses—The supply is limited. It will be rather easy to get this wood in small dimensions. In South India it is liked very much for house-building especially for posts, beams, rafters, door and window frames and planking ; locally also used for plough-handles. It may be worthwhile to try this for turnery work.

Gross structure of the wood

(*Shorea argentia*, *S. assamica*, *S. buchanani*, *S. farinosa*, *S. gratissima*, *S. obtusa*, *S. robusta*, *S. sericeiflora*, *S. talura*, *S. tumbuggaia*)

[Pl. **20**, 118–120 ; Pl. **21**, 121–126 ; Pl. **22**, 127–132 ; Pl. **23**, 133]

All are diffuse-porous woods but on rare occasions a tendency may be noticed for semi-ring-porousness (*S. argentea*, *S. assamica*, *S. farinosa* and *S. gratissima*). *Growth rings* usually absent or indistinctly marked, 2–6 rings per cm. ; occasionally bands of comparatively thick-walled flattened fibres with scanty pores (*S. assamica*, *S. talura*, *S. tumbuggaia*) give the impression of growth rings ; other anatomical structures which also give the impression of growth marks are (1) fine concentric, soft tissue or parenchyma bands with

with radially fattened fibres in the neighbourhood (*S. argentea*, *S. farinosa*, *S. robusta*) and (2) occasional thick concentric bands of gum ducts (*S. buchanani*, *S. robusta*, *S. tumbuggaia* and others) ; their occurrence and distribution are, however, too erratic to be regarded as true growth rings. *Pores* moderately large and fairly distinct to the eye (*S. assamica*, *S. buchanani*, *S. gratissima*, *S. robusta*, *S. sericeiflora*) to small and not visible to the eye (*S. argentea*, *S. talura*, *S. tumbuggaia*) ; moderately few (5–10 per mm.^{2}) as in *S. argentea*, *S. assamica*, *S. farinosa*, *S. gratissima*, *S. robusta* and *S. talura* to sometimes few (2–5 per mm.^{2}) in *S. buchanani*, *S. farinosa* and *S. sericeiflora* ; occasionally may be also moderately numerous (10–20 per mm.^{2}) in *S. robusta* and *S. tumbuggaia* ; distribution of the pores more or less uniform, majority solitary in *S. argentea*, *S. buchanani*, *S. farinosa*, *S. gratissima* and *S. talura* or in radial or partly oblique pairs, sometimes alinged in somewhat oblique or diagonal lines forming inconspicuous 'zig-zag' pattern as in *S. assamica*, *S. farinosa* and *S. sericeiflora* but less frequently aligned in tangential lines or rows (*S. farinosa*, *S. sericeiflora*, *S. tumbuggaia*) ; in shape majority roundish to somewhat oval in certain species ; tyloses usually scanty in soft and lighter shoreas like *S. argentea*, *S. assamica*, *S. buchanani*, *S. farinosa*, *S. gratissima* and *S. sericeiflora* to abundant, and almost completely fill up the pore cavity in *S. obtusa*, *S. robusta* and *S. tumbuggaia* ; vessel lines very conspicuous in *S. assamica* and occasionally also in *S. argentea*. *S. farinosa*, *S. gratissima* and *S. robusta* ; frequently inconspicuous in *S. taura* and *S. tumbuggaia*. *Soft tissues* rather scanty to fairly abundant, just visible to indistinct to the eye ; (1) often present round the pores forming a narrow sheath (*S. argentea*, *S. assamica*, *S. robusta*, *S. sericeiflora*) round in pores or pore groups ; (2) sometimes aliform or 'eyelet', occasionally extending sideways and joining similar extension from other pores (*S. assamica*, *S. farinosa*, *S. gratissima*, *S. sericeiflora* and *S. tumbuggaia*) ; (3) diffuse to fine short tangential lines, very scanty to fairly abundant, visible only under lens (*S. robusta*, *S. talura*, *S. tumbuggaia*) ; (4) occasionally irregularly spaced, concentric lines of soft tissue simulating growth marks often present in S. *argentea*, *S. farinosa* and *S. robusta* ; (5) continuous or broken bands of sfot tissue embedding gum canals usually present in all ; usually narrow but sometimes fairly broad and prominent to the eye. In sal, which has wide distribution in North India, remarkable variation in soft tissue is met with from scanty to abundant, and also in the occurrence and distribution of different types. This along with the size and frequency of pores and rays is responsible in bringing about variation in their physical properties. *Rays* fine to moderately broad, barely visible to distinct to the eye, spaced apart to fairly closely spaced on the end surface ; indistinct to distinct on the tangential surface as brown, spindle shaped mass, sometimes moderately numerous ; ray flecks often conspicuous on the radial surface. *Gum ducts* vertical, usually smaller than the pores, just visible to distinct to the eye, often present in short or long tangential bands on the end surface, very irregularly spaced ; white

gummy deposits often fill up the cavity of the ducts which make them visible on all the surfaces of the wood ; gum ducts may be in one or more rows. *Ripple marks* normally absent but occasionally a tendency towards storied arrangement may be noticeable locally as in *S. assamica* and *S. robusta*.

Material—

S. argentea – 6579 Burma (0·74), 7152 Burma (0·93).

S. assamica – 3369 Makum, Assam (0·51), 4411 (0·57), 4698 Dibrugarh, Assam (0·50), 5174 Lakhimpur, Assam (0·57), 5661 Lakhimpur, Assam (0·64), 5847 Assam (0·52), 5982 Pegu, Burma (0·68), 6512 Burma (0·61), 7240 Lakhimpur, Assam (0·58), 7513 Lakhimpur, Assam (0·49), 7604 Lakhimpur, Assam (0·51).

S. buchanani – 6673 Burma (0·74).

S. farinosa – 6606 Burma (0·57), 6913 Burma (0·65), 6914 Burma (0·48), 6915 Burma (0·68).

S. gratissima – 6684 Burma (0·70), 6916 Burma (0·66), 6917 Burma (0·70), 7139 Burma (0·74).

S. obtusa – 283 Burma (0·94), 555 Burma (0·87), 556 Burma (0·91), 6847 Burma (0·89), 6851 Burma (1·12), 6927 Burma (1·10), 7135 Burma (0·84).

S. robusta – 204 Garhwal, U.P. (0·85), 388 Oudh, U.P. (0·73), 497 Darjeeling (0·83), 635 E. Duars, Bengal (0·82), 702 Darjeeling (0·88), 873 Kumaon, U.P. (0·96), 1235 Andhra (0·75), 2322 Darjeeling (0·8), 2990 Garhwal (0·88), 3137 Buxa, Bengal (1·00), 3138 Buxa, Bengal (0·93), 3385 Rangpore, E. Bengal (0·89), 3434 Palamow (damaged), 3440 Palamow (0·75), 3478 Singhbhum, Bihar (0·69), 3516 Khurda Forest, Orissa (0·72), 3556 Khurda Forest, Orissa (0·68), 3624 Darjeeling (0·93), 3625 Darjeeling terai (0·71), 4000 Andhra (0·73), 7260 Nowgong, Assam (0·85), 7266 Kurseong, Bengal (0·94), 7271 Jalpaiguri, Bengal (0·92), 7280 Goalpara, Assam (0·93), 7334 Darrang, Assam (0·87), 7455 Sylhet (0·84), 7456 Sylhet (0·85), 7475 Rajabhatkhawa, Bengal (0·89), 7548 Kamrup, Assam (0·72), 7577 Kamrup, Assam (0·88), 7686 Hoshiarpur, Punjab (0·83), 7687 Hoshiarpur, Punjab (0·85), 7689 Mauharpur, Bihar (0·84), 7690 Mauharpur, Bihar (0·85), 7691 Mauharpur, Bihar (0·83), 7692 Nahan State, H.P. (0·86), 7693 Nahan State, H.P. (0·84), 7694 Nahan State, H.P. (0·81), 7734 Puri, Orissa (1·00), 7740 Balliguda, Orissa (0·82), 7741 Balliguda, Orissa (0·87), 7742 Balliguda, Orissa (0·85), 7743 Balliguda, Orissa (0·88), 7752 S. Bastar, Jagdalpur (0·91), 7754 N. Bastar, Jagdalpur (0·82),

7755 Sambalpur, Orissa (0·94), 7835 Patna, Orissa (0·89), 7933 Porahat, Bihar (0·79), 7934 Porahat, Bihar (0·91), 7935 Porahat, Bihar (0·85), 7936 Porahat, Bihar (0·88), 7937 Porahat, Bihar (0·84).

S. sericeiflora – 6753 Burma (0·78), 6918 Burma (0·73), 6919 Burma (0·79).

S. talura – 3895 Cuddapah (0·73), 6185 Salem, Madras (0·75), 6211 Ootacamund, Madras (0·79).

S. tumbuggaia – 1062 Cuddapah (0·98), 1078 N. Arcot (1·06), 3894 Cuddapah (1·09), 5496 E. Cuddapah, Madras (0·99), 5497 E. Cuddapah, Madras (1·01), 6075 E. Cuddapah, Madras (0·99), 6869 Madras (0·97).

9. VATERIA L.

Vateria at present is a small genus and includes only three well-defined species. These are large trees and are confined to only Indian region. Two of these namely *V. indica* L. and *V. microcarpa* Gupta grow in the southern and western part of India and the third one (*V. acuminata* Hayne) in Ceylon. Unfortunately this genus has not so far received any serious attention from botanists with the result that there is considerable confusion with its systematic position *vis-à-vis* other genera of the family. For example, the monotypic genus *Vateriopsis*, endemic in Seychelles Island, is considered by some to be similar to the Indian Vaterias or their derivatives. Further, the status of two other genera *Stemonoporus* Thw. and *Monoporandra* Thw., both endemic in Ceylon, with that of *Vateria* is most confusing. At present *Monoporandra* Thw., does not seem to have any generic status because it has been included by some workers under *Vateria*. As regards *Stemonoporus* Thw., it is still recognized by some as a distinct genus but whether it will be able to maintain its status as such is doubtful. Already systematists, other than Symington had placed *Stemonoporus* along with *Vateria*. When the position of *Vateriopsis*, *Monoporandra*, and *Stemonoporus* is clarified *vis-à-vis* vaterias, the exact number of the species included under the latter genus will then be definitely known.

The trees of this genus are important from the point of view of timber, oils, and resins. *V. acuminata* Hayne, a tall tree of Ceylon produces one of the best dammars known as *hal-dummala*. This resin is of beautiful, clear, yellowish colour and is suitable for fine varnishes. The fruit of this tree is eaten. The use of bark is also prevalent in the preparation of jaggery in which it arrests its fermentation to "toddy". In Ceylon the timbers have had great demand in the past for tea-boxes. The two Indian species have very similar timbers which can not be distinguished for practical purposes.

1. **V. indica** L. Syn. *V. malabarica* Blume—**vellapine.** *Bilidupa, velthapaini* (Coorg), *dhupa, dhupada, gugle, illupathla, maddi dhupa, munda dhupa, paini* (Kan.), *paini mara, payani, perum piney, vella kondrikam* (Mal.), *ajakarna* (Sans.), *dhup maram, kondricam, piney maram, vallay kungiliam, vellei kundrikam* (Tam.), *dhupada, telladamaru* (Tel.); also known as Indian copal tree, piney varnish tree, pinkey varnish tree, white dammar tree and white *dhup* or Malabar white pine. A large handsome evergreen tree up to 30 m. in height with a clean cylindrical bole of about 15 m. in length and about 3·7 m. to 4·6 m. in girth. *Bark* smooth, whitish to grey, sometimes blotched with green and white. Bark is bitter and acrid. It has many uses in Ayurvedic medicine. It is said to cure cough, anaemia, ear diseases, urinary troubles, ulcers, wounds and skin eruptions; also reported to be effective in dysentery, leprosy and itches. Tannin is obtained from the fruit rind (about 25%), while kernel of seed yields fat called as vateria fat, Malabar tallow or piney tallow. Its various uses are for candle making, soap making and sizing cotton yarn; also used for medicinal purposes for local application in chronic rheumatism and other painful affections. Its misuse is as an adulterant of *ghee*.

The tree yields an important oleoresin for which trees are tapped in two ways. In one case, the trees are wounded by making an incision in the trunk at the beginning of the dry season. The flow starts within three or four days and continues for about two or three months. In the other case, fire is lighted at the foot of the tree with the result that bark cracks with the heat and the flow of resin starts. Though by this method more yield can be obtained but very often trees are killed in the process. This oleoresin, which is a valuable minor forest product, is used as an incense and also in paints and varnishes (for carriages and furniture). It varies in colour from white to yellow to bright orange, light green or dark coloured. When this is distilled, a high percentage of essential oil is obtained. The resin forms a good ointment and when mixed with coconut oil, makes an excellent copal-like varnish. Fine shavings of this resin are given as a medicine for diarrhoea.

It is mainly distributed in the evergreen forests of Western Ghats up to 1,200 m., also from North Kanara to Travancore and Malabar. Usually common in the forests of lower hills up to 750 m. and also frequently planted as an avenue tree (with white fragrant flowers) in Mysore, Bombay, Malabar and Travancore.

Description of the wood—See page 160.

2. **V. macrocarpa** Gupta—**vellapine.** *Vellapayeni, vellappina* (Mal.). A small tree of about 7·5 m. or more with 4·5 m. clean bole and diameter at breast height about 1·2 m. It is similar to *V. indica* Linn. and can only be distinguished from it by large flowers, smaller triangular sepals and larger fruits. First collected by M. A. Latham, Conservator of Forests, Madras in 1926 and identified as a distinct species by B. L. Gupta.

It grows in South India in the forests of Muthu Kulam, Bolampatty range, Palghat division, Mysore.

Description of the wood—See below.

Description of the wood
(*Vateria indica* and *V. macrocarpa*)
[Pl. 23, 134–136]

General properties—Sapwood usually white or creamy in colour but sometimes dirty grey ; heartwood whitish-grey or light yellowish-buff turning brownish or pinkish-buff on exposure ; wood with resinous smell when fresh ; soft to moderately hard ; moderately heavy (sp. gr. 0·53–0·68 air-dry), often interlocked-grained in narrow bands ; medium coarse and even-textured ; somewhat lustrous when firstly cut with conspicuous ray-fleck on the radial surface.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct. *Pores* moderately large to small, sometimes hardly visible to the eye, moderately few to numerous (5–25 per mm.^{2}), evenly distributed, solitary or in pairs or sometimes in clusters of 2–5 and often forming irregularly arranged oblique groups in *V. macrocarpa* ; round to oval, mostly open, occasionally filled with gum, tyloses partially fill up the pores ; vessel lines somewhat conspicuous. *Soft tissues* (including tracheids) inconspicuous to the eye, but visible only under lens round the pores or pore groups ; also faintly noticeable round the gum ducts as a thin layer. *Rays* visible to the eye, rather widely spaced, often brownish in colour, and show silver grain effect on the radial surface. *Gum ducts* minute, usually attracts attention as white specks to the naked eye, distinctly visible with a lens, uniformly scattered, mostly single, rarely in tangential rows ; white gummy deposits often fill up the cavity of the ducts both in the end and longitudinal surfaces.

Strength—Chelvarajan has found out recently the nail holding power of *V. indica* as given below :—

Average load required in lb. to pull			
1″ of nail from		1¼″ of nail from	
Side grain	End grain	Side grain	End grain
104	115	117	124

For the rest of the test figures, please see appendix I.

Seasoning—Usually seasons fairly well but in green condition it is liable to grow blue-stain and mould. Therefore, green conversion and quick drying is very necessary. Quick surface drying in vertical stacks, followed by horizontal stacking under shade with a good circulation of air is recommended. Once dried the wood behaves steadily. The wood develops a certain amount of cupping and warping, hence careful stacking is necessary. Kiln seasoning should be done with some care as there is a considerable difference between the rate of drying of wood from the outer and the inner portions of a log. According to I.S.I., Specifications it is least refractory ("C" category) in air seasoning.

Natural durability—It is not a durable timber and preferably should not be used in exposed conditions without treatment. *V. indica* has been found to last for 23–28 months in contact with the ground.

Insect and fungus attack—Logs and converted timber are liable to be attacked by a few species of the families Anobiidae (dry wood borer), Bostrychidae (powder-post beetles), Brenthidae, Cerambycidae and Lyctidae (powder-post beetles) of the order Coleoptera. It is easily susceptible to discolouration and decay.

Preservative treatment—The heartwood is very refractory to treatment ; side and end penetration is practically nil. For plywood and battens the following treatment should be given :—

(*a*) For plywood the veneers shall be treated with 1·26% hot solution (200° to 212°F., or 93° to 100°C.) of boric acid or 1·9% of hot solution of borax for 10–40 minutes based on species and thickness of veneers. These should then be dried and moisture content brought to about 10% before bonding.

(*b*) For battens treatment recommended is a 6% zinc chloride, boric acid or borax solution for two hours in a hot solution at about 140°F. followed by immersion in cold solution for one hour.

Working qualities—The wood is easily worked and saws and finishes to a smooth surface. It takes good polish also. Due to interlocked fibres, hand finishing sometimes may be necessary. It requires no boiling or steaming treatment and can be peeled green. In this method veneers become woolly and coarse. Better veneers are obtained if a boiling treatment in water at about 170°F. for a period of about 12 minutes per cm. of diameter of log is given. The cutting edge of the knife should be kept low on account of the woolly nature of the wood. The veneers season easily without much degrade and also take glue well. Ramamritham and Narasimhan have studied *V. indica* as regards its suitability for aircraft quality plywood. Using both core and face veneers of vellapiney, they found the plywood poor in resistance to water and bending qualities. Moreover, it was excessively knotty. The wood is not suitable for ornamental work due to uninteresting colour and texture.

Supply and uses—The supply is available only from the south and west coast of India. It is most common in south-west of Madras, Coorg and Travancore-Cochin (Kerala) wherefrom large supplies are available. The quantity available from west coast of Bombay is small.

It is a well known wood of South India and is much used for tea-boxes, packing cases, coffins, planking, interior fittings of buildings, floorings, ceilings, cordite cases, ammunition boxes, and temporary construction. It is also sold in Bombay market as "Malabar white pine" similar to imported "deal" woods. Recently it has come into prominence in the plywood industry of the south. Durable plywood suitable for trunk making, opium cases, painted ceilings, partitions and such other works can be made. It has been tested for tea-chest and found suitable being free from offensive smell. The wood has been tested for match industry and has been found useful. It is a very good wood for oars used for sea going vessels.

Material—

V. indica – 747 S. Kanara (0·63), 1187 S. Kanara (0·60), 4586 Travancore (0·62), 5853 S. Kanara (0·61), 5929 S. Kanara (0·53), 6335 S. Mangalore (0·68).

V. macrocarpa – 6727 Palghat, Madras (0·64), 7958 Bolampatty Range, Madras (0·61).

10. VATICA L.

Vatica is a large genus and includes at present about 87 species, usually small to moderate-sized resinous trees, occasionally shrubs. Large trees up to 49 m. height and 97 cm. diameter have also been recorded in certain areas. It is widely distributed, the western limit being Western Ghats, South India and Ceylon. After passing through Assam, Burma, Indo-China, Thailand, Malay Peninsula, Sumatra, Borneo, it reaches its eastern limit in New Guinea. The largest number of species are, however, found to occur in Borneo (35) and Malaya (29). In its northernmost limit of distribution, only one species is reported to grow in Hainan in China and nine in the Philippines. India proper has two species, one in South India and the other in Assam in eastern India, while Burma is reported to have five including one common both to eastern India and Burma. Ceylon has three species.

Previously considerable confusion existed between the genera *Sunaptea* (*Synaptea*), *Pachynocarpus* and *Vatica*. Several botanists praticularly Burkill, Foxworthy and Symington gave considerable thought to these difficult genera and reduced them all to *Vatica* L. Originally Gilg and Brandis, recognized under *Vatica* three sub-genera *Retinodendron* (Korth) Benth., *Isauxis* Burck. and *Synaptea* Burck., while Van Slooten in monographing *Vatica* made

three sub-genera – *Synaptea* (Griff.) Brandis, *Isauxia* (Arn.) Brandis and *Pachynocarpus* (Hook. f.) V.Sl. But recently Symington taking into consideration systematic and anatomical features has decided to group them under *Vatica*. Again, Desch while studying the anatomical structure of Malayan dipterocarps, recognized great similarity of structure between the woods of *Cotylelobium*, *Upuna* and *Vatica*. As the taxonomy of all these genera are not well-defined, a careful investigation of the status of the various allied genera both from systematic and from anatomical point of view is likely to yield interesting results.

Unlike many dipterocarps which are generally characterized by their large size, buttressed trunk and fissured bark, vaticas are rather small in size, unbuttressed and with smooth bark. In the forests they do not usually appear like dipterocarps and are, therefore, often confused with other trees. According to Symington *Xanthophyllum*, *Sindora*, *Lophopetalum*, *Parinarium*, *Helicia* and even some trees of *Annonaceae* are often confused with vaticas.

Resin is found in all trees except a few species ; the quantities available are rather small and not, therefore, of much commercial importance. *Vatica roxburghiana* Blume (mendora) of Ceylon is reported to yield abundant resin, which is transparent and yellowish in colour and is used for varnish. Both solid resin and aromatic oleoresin are produced by these trees and their colour may vary from clear white to pale yellow or sometimes greenish. Some dammar is said to be collected from vatica trees in Indo-China and Indonesia.

The bark of the trees are used in Ceylon, and Malay Peninsula to prevent fermentation in toddy.

Of the six species so far recorded from India and Burma, woods of only four are available for study. However, woods of all these species are similar in appearance and structure, and it is not possible to separate them*.

1. **V. dyeri** King—vatica. *Kanyin-kyaungkye* (Burm.). A tree of Tenasserim, Burma.

Description of the wood—See page 164.

2. **V. faginea** Dyer—vatica. A tree of Tenasserim, Mergui, Burma. Symington has included this under a new combination, *V. odorata* (Griff.) Sym. It is distributed from Tenasserim, Indo-China to the Malay Peninsula. In the latter country, it is known as *resak ranting kesat*.

Description of the wood—See page 164.

3. **V. grandiflora** Dyer—vatica. A tree of lower Burma. Symington has included this under *V. odorata* (Griff.) Sym.

Description of the wood—See page 164.

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* *Vatica scaphula* Dyer (mascal wood) described by Pearson and Brown is *Anisoptera scaphula* Pierre, of Chittagong, Arakan and Mergui.

4. **V. griffithii** Brandis—vatica. A tree of Myitkyina, upper Burma.

Description of the wood—See below.

5. **V. lanceaefolia** Blume—vatica. *Dieng-soh-kaina, kalang-asing, keyo-asing, kham-khor, khirkha-champa, lamakur, mekruk, mir-kom-phor, moal, mohal, morakur, morhal* (Asm.), *panthitya* (Burm.). A small to medium-sized evergreen tree. *Bark* almost smooth, thin, grey to greenish-grey.

Except probably in North-East Frontier, it is common in evergreen forests of Assam up to 900 m., sometimes with a tendency of gregarious habit round the swamps. It also extends to upper Burma where it grows on the Irrawady above Bhamo.

The tree when tapped yields a clear, white, aromatic oleoresin. On hardening, it appears as light amber colour. Its local use is for incense. When distilled, a scented balsam is also obtained which is commonly known as *chua* and is used to flavour tobacco for chewing with *pan* (beetle leaves). The strong-smelling balsam, also known as *ghund*, is said to be used in religious ceremonies.

Description of the wood—See below.

6. **V. roxburghiana** Blume Syn. *V. chinensis* Linn.—vatica. *Cheru piney* (Mal.), *mendora* (Sinh.), *vellei payin* (Travancore). A medium-sized to large tree. *Bark* smooth pale grey.

It is found in the evergreen forests of South Kanara, Malabar and Travancore. Also occurs in the west of Ceylon, usually near the rivers.

Description of the wood—See below.

Description of the wood

(*Vatica faginea, V. grandiflora, V. lanceaefolia* and *V. roxburghiana*)

[Pl. **23**, 137–138 ; Pl. **24**, 139]

General properties—Sapwood and heartwood generally distinct. Sapwood pale yellow to light yellow-brown or grey ; heartwood light brown or yellowish-brown, darkening on exposure to reddish-brown or red (*V. roxburghiana*). Sometimes white gummy deposits visible to the eye both on the end as well as on the longitudinal surfaces in *V. faginea* and *V. grandiflora*. Wood moderately soft to hard to very hard ; moderately heavy to very heavy (sp. gr. 0·65–1·06 air-dry) ; straight to somewhat interlocked-grained ; rather fine as in *V. lanceaefolia* and *V. roxburghiana*, to medium coarse or coarse-textured in *V. faginea* and *V. grandiflora*. Like Indian vaticas, woods from Malay Peninsula and other South-East Asian countries also show considerable variation in their general properties being moderately heavy to very heavy (41–66 lb. per cu. ft. at 15% m.c. or 657–1057 kg. per cu. m.), durable or non-durable, and medium coarse to fine-textured.

Gross structure—All are diffuse-porous woods. *Growth rings* generally indistinct, occasionally faintly demarcated by narrow bands of flattened fibres, sometimes in *V. faginea*, and rarely in *V. lanceaefolia* by fine tangential lines of soft tissue or rarely due to the crowding of pores in tangential row, 3–5 rings per cm. *Pores* small, not visible to the eye, moderately numerous to numerous (13–37 per mm.^{2}), evenly distributed, often solitary (*V. roxburghiana*) or in irregular oblique pairs of 2–3 or more (*V. faginea*). Sometimes appear crowded due to somewhat tangential to radial grouping of pores in *V. lanceaefolia*; round to oval, mostly open, occasionally filled with tyloses; vessel lines not prominent. *Soft tissues* distinct only under lens, not abundant except sometimes in *V. lanceaefolia*, usually present as a thin incomplete sheath round the pores or pore groups, or inconspicuous eyelets, diffuse or in fine tangential lines simulating growth marks; indistinct round the gum ducts. *Rays* distinct under lens, two types, fine to very fine, a few very fine ones in between the comparatively broader ones, medium spaced, and usually do not show up well on the radial surface. *Gum ducts* minute, visible under only lens but sometimes distinguishable to the eye due to the presence of whitish gummy deposits, rather irregularly distributed, at times scanty, round, smaller than the pores, mostly single, occasionally in short groups of 1–3 and rarely in tangential rows. *Pith flecks* occasionally present.

Strength—These are usually hard and strong timbers except sometimes *V. lanceaefolia*. Strength data of *V. roxburghiana* given by Prof. Unwin is given below :—

Weight	59·70 lb./cu. ft. (956·30 kg./cu. m.)
Resistance to shearing along fibres	620·4 lb./sq. in. (43·62 kg./sq. cm.)
Crushing stress	2·619 tons/sq. in (412 kg./sq. cm.)
Coefficient of transverse strength	6·125 tons/sq. in. (965 kg./sq. cm.)
Coefficient of elasticity ...	835·4 tons/sq. in (131,565 kg./sq. cm.).

Strength data of *V. lanceaefolia* is given in appendix I. For the rest no figures are available. Desch gives only weight for *V. odorata* Syn. *V. faginea* and *V. grandiflora* as 59·9 to 65·8 (62) lb. per cu. ft. [960 to 1054 (993) kg. per cu. m.] at 15% moisture content.

Seasoning—Tests have not been made but samples in the timber collection reveal checks in many cases and certain amount of cupping. As regards Malayan timbers, Desch quoting Walker records green to oven dry shrinkage figures as follows: "radial 5·4 and tangential 9·6 per cent. Boards of *V. cuspidata*, 1½ in. thick and 2¼ to 7 in. wide, dried slowly taking 6 months to dry from 45 to 16 per cent moisture content. The percentage of shrinkage figures

was; radial 0·8 and tangential 3·3 per cent; figures from green to oven-dry were 4·2 and 10·2 per cent respectively".

Natural durability—Not durable, average heartwood of *V. lanceaefolia* lasts less than 2 years. It is reported that *V. roxburghiana* is durable underground. According to Desch the natural durability of vaticas of Malay Peninsula varies appreciably. Sometimes two classes are recognized there – one very durable and the other not durable. The latter group is often characterised by large amount of sapwood, the heartwood much softer and lighter.

Insect and fungus attack—Logs and converted timber of *V. lanceaefolia* are liable to be attacked by powder-post beetles (Bostrychidae, Lyctidae and others). Pin-hole and shot-hole borers of the families Platypodidae and Scolytidae (Coleoptera) have also been reported from this timber. In Malayan species, powder-post beetle-attack in sapwood of several species has been reported (Desch). Fungus attack has sometimes been noticed in microscopic sections of *V. faginea* and *V. lanceaefolia*.

Preservative treatment—As timbers of vatica are not of much commercial importance, data regarding treatment is lacking. Its utilization, therefore, depends much on its natural durability. However, *V. lanceaefolia* has been tested at Dehra Dun, and its heartwood has been found to be only partially treatable.

Working qualities—Timber is usually difficult to saw except *V. lanceaefolia* which is sometimes easy to saw and work with. Tests carried out in Malaya on *V. cuspidata* and *V. stapfiana* indicate that both these species are also difficult to saw, probably due to the clogging of the teeth by gummy resin (Desch). Heavy resin contents sometimes affect planing, yet a good finish is often obtained. According to Reyes, vaticas of Philippine island are not difficult to work and sometimes polish very highly.

Supply and uses—At present the supply is very limited due to lack of demand; more timber can be obtained from *V. lanceaefolia* which is locally common and found growing gregariously round swamps in Assam. It is often mixed up with *Hopea* and sold in the market as such. The timbers of other species are not much in use. It is reported that *V. roxburghiana* is good for underground purposes while *V. lanceaefolia* is suitable for planking. Its present use is mostly for firewood. It gives excellent charcoal. However, on account of its natural durability, harder timbers can be used for heavy constructional work. According to Desch its only use in Malaya is for house posts. Reyes, however, reports various uses for Philippine vaticas. Woods with finer-texture and straight grain are suitable for shuttles and bobbins, rulers, tripods, scientific instruments and novelties; strong, heavy and very durable ones for high grade constructional work, telephone and telegraph poles and for salt-water piling when creosoted.

Material—

Vatica roxburghiana – 4729 Travancore (0·93).

V. faginea – 6589(*a*) Burma (0·99), 6921 Burma (0·82), 6922 Burma (0·91), 6923 Burma (1·06), 6924 Burma (0·87), 6930 Burma (0·86), 7148 Burma (0·95).

V. grandiflora – 6785 Upper Burma (0·82).

V. lanceaefolia – 6860 Cachar (0·65), 7168 Upper Burma (0·90).

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S. S. GHOSH.

16. MALVACEAE

The systematic position of the *Malvaceae* and the next four families described in this volume, as well as the grouping of some of the genera included in them, have been a subject of considerable study by both taxonomists and anatomists. However, there seems to be no agreement among the taxonomists. As far as the anatomical structure of the secondary xylem, particularly of the genera described here is concerned, the families *Malvaceae*, *Bombacaceae*, *Sterculiaceae* and *Tiliaceae* show great similarity, while the *Elaeocarpaceae* stands out apart. Further co-operative research among botanists specializing in different disciplines, can only clarify the systematic position of the members of this group.

The *Malvaceae*, as it is commonly understood today, consists of about 80 genera and well over a thousand species, most of which are herbs and shrubs, but a few are trees. Though widely distributed and represented all over the world, the family reaches its best development in the American tropics. Anatomically it constitutes a more or less compact and homogeneous group, closely resembling the *Bombacaceae* which is included by some botanists under the *Malvaceae*.

The economic importance of the family is to some extent due to the floss and fibre obtained from some of the genera. The seed-hairs of various species of *Gossypium* provide the well-known cotton fibre of commerce. The inner bark of some species yields a useful fibre like deccan hemp from *Hibiscus cannabinus* L. and rozelle hemp from *H. sabdariffa* L., used for textiles as well as cordage. Fibres of some commercial importance, used chiefly for rope-making are also obtained from *Abutilon avicennae* Gaertn., *Sida rhombifolia* L., *Kydia calycina* Roxb., *Urena lobata* L., *Hibiscus tiliaceus* L. and *Thespesia populnea* Correa. The green fruit of *Hibiscus esculentus* Linn. commonly known as *bhindi* or *okra*, are cooked and served as a vegetable or soup, while the ripe fruits of *H. sabdariffa* are used for making jam. The seed of cotton is rich in oil which is edible and suitable for cooking, while the seed cake constitutes an important source of cattle food in India. The woods of the family are mostly of local importance. The West Indian genus *Montezuma* produces a handsome figured timber used locally in Cuba and Puerto-Rico for furniture and musical instruments. Another timber of some local importance is vidals lanutan [*Bombycidendron vidalianum* (Naves) Merril and Rolfe] of the Philippines, which is in demand for vehicle shafts, gun-stocks, cabinet-work and musical instruments like mandolins, guitars, etc. Other genera like *Hibiscus*, *Thespesia* and *Kydia* also furnish timbers which are of local importance.

The family is represented in the Indian region by about 15 genera of which 5 include trees. Three of these for which wood specimens were available for

study are described here. Of the other two, *Dicellostyles* Bth. is represented by two tree species, *D. jujubifolia* Bth. *dantagla* (Lep.), *kubinde* (Nep.) of the hills of Sikkim and Bhutan, and *D. axillaris* Bth. of Ceylon, while *Julostyles* Thw. has only a single representative *J. angustifolia* Thw., which is a slender tree endemic in Ceylon.

The woods of the genera dealt with here, show a clear distinction into sapwood and heartwood, the former being usually white and rather wide and the latter ranging in colour from light brown with a faint purplish tinge to chocolate or deep purplish-brown with darker streaks. Wood soft to moderately hard and light to moderately heavy in *Hibiscus* and *Kydia*, but harder and heavier in *Thespesia*. Pores moderately large or medium-sized to small, mostly solitary and in short radial multiples, with some clusters, few to moderately few in *Kydia* and *Thespesia* but generally more numerous in *Hibiscus*. Soft tissues both paratracheal and apotracheal present ; the former scanty and not visible in *Thespesia*, narrowly vasicentric in *Kydia* with a tendency to be aliform in *Hibiscus* particularly *H. tiliaceus* ; the latter invariably storied, predominantly diffuse to diffuse-aggregate and somewhat indistinct or just visible in *Hibiscus* and *Thespesia*, but clearly seen in *Kydia* as fine tangential lines about 3–7 per mm. forming a distinct reticulum. Rays mostly fine and low, usually less than 0·5 mm. in height in *Hibiscus* and *Thespesia* but rather broad and up to 2 mm. or more in height in *Kydia* ; the low rays often storied. Ripple marks usually present, due to storied parenchyma, storied rays or both, sometimes rather faint and indistinct.

Key to the genera

1. Soft tissues predominantly diffuse to diffuse-aggregate in fine, closely spaced, broken lines, somewhat indistinct or just visible even under lens ; rays fine, usually forming inconspicuous flecks 2

1. Soft tissues distinctly visible, predominantly reticulate in fine widely spaced tangential lines ; rays broad to fine, often forming conspicuous flecks ... ... *Kydia*

    2. Soft tissues round the pores not visible even under lens. Wood usually hard and heavy ... ... *Thespesia*

    2. Soft tissues round the pores vasicentric to aliform, fairly distinct. Wood usually soft to moderately hard and light to moderately heavy ... ... *Hibiscus*

1. HIBISCUS L.

A genus of about 200 species, widely distributed in the tropical and temperate regions. The majority are herbs and shrubs ; only a few attain tree size.

Over 30 pecies are known to occur in India, of which only two, viz., *H. tiliaceus* L. and *H. macrophyllus* Roxb. grow into tree size and are considered here. The woods of the two species are very similar and often difficult to separate. *H. tiliaceus* is however, usually a little finer-textured and shows better development of aliform parenchyma.

1. **H. macrophyllus** Roxb.—*kachia-udal*, *kasyapala* (Beng.), *yetwun* (Burm.), *chamia* (Cachar), *mao-marli* (Garo), *misi-mugrong-buphang* (Kach.), *tyllendkhar* (Kh.), *kong-krowai* (Kuki), *baiza* (Lush.), *pharna* (Mik.), *pohu udal* (Sibsagar), *chamia* (Sylhet), *jabo* (Tippera). A small to medium-sized tree, growing in Burma to a height of 9–15 m. with a clear bole of 4·5–9 m. and a girth of 1–1·5 m. *Bark* grey or light brown, rather smooth and fibrous, about 6 mm. thick.

In India proper, it is found only in Assam. It also grows in Chittagong, Burma and Malaya.

Description of the wood—See below.

2. **H. tiliaceus** L.—Known as mahoe in United Kingdom. *bola*, *chelwa* (Beng.), *thengpen*, *thinban* (Burm.), *bellipata* (Kan.), *attuparatthi*, *nirparatthi* (Mal.), *belapata* (Mar.), *beligobel*, *belipatta* (Sinh.). A small tree usually crooked up to 9 m. in height and 30–90 cm. in girth. *Bark* light brown or grey in colour, smooth in young trees, but later becomes somewhat rough and fissured, fibrous inside, about 6 mm. thick.

Commonly found on the beach and in the tidal forests along the sea coast in West Bengal, Bombay, Kerala, Madras, Mysore and the Andamans. It also occurs in Ceylon, Burma and Malaya.

Description of the wood—See below.

Description of the wood

(*Hibiscus macrophyllus* and *H. tiliaceus*)

(Pl. **24**, 140, 141)

General properties—Sapwood creamy-white or greyish-white to pale buff, sharply defined, wide ; heartwood rather small, usually light to dark purplish-brown, sometimes with a yellowish or reddish-brown or even greenish tinge, soft to moderately hard ; somewhat light to moderately heavy (sp. gr. 0·52–0·74 air-dry) ; dull to somewhat lustrous particularly in *H. macrophyllus* ; straight to slighly interlocked-grained and medium to fine-textured.

Gross structure—Both are diffuse-porous woods. *Growth rings* usually indistinct, but sometimes fairly distinct marked by slightly denser latewood and a somewhat discontinuous line of soft tissue, 1–5 per cm. *Pores* moderately large to small, usually somewhat larger and more clearly visible to the eye in

H. macrophyllus, but smaller and just visible or indistinct to the eye in *H. tiliaceus*, usually few to moderately numerous (2–14 per mm.^{2}) in the former, but moderately numerous to very numerous (13–45 per mm.^{2}) in the latter, evenly to somewhat unevenly distributed, mostly solitary and in radial multiples of 2 or more, also in clusters of 3–12, round to oval in outline, usually open; vessel lines usually straight, visible to the eye, but finer in *H. tiliaceus* than in *H. macrophyllus*. *Soft tissues* both paratracheal and apotracheal; paratracheal not visible to the eye, but clear under hand lens, usually vasicentric, forming a distinct whitish halo or sheath round the pores and also occasionally with lateral wing like extensions, tending to be aliform confluent in *H. tiliaceus*; apotracheal not visible to the eye, indistinct or barely visible with lens, diffuse to diffuse aggregate, appearing as fine dots or short broken tangential lines, sometimes connecting adjacent rays; occasionally also in a narrow concentric layer delimiting the growth rings, indistinct to the eye, but clearly visible with a lens as a fine whitish somewhat discontinuous line. *Rays* fine to very fine, just visible to the naked eye, often touching or curving round the pores, fairly widely spaced, forming an inconspicuous fleck, generally not more than 0·5 mm. in height, distinctly storied to just a suggestion of storied arrangement. *Ripple marks* usually present, distinct and well defined to faint and just visible to the eye, 28–36 per cm. *Gum canals* of the traumatic type observed in one specimen of *H. macrophyllus*.

Strength—Only a small consignment of *H. macrophyllus* has been tested at Dehra Dun. For strength figures please see appendix I.

Seasoning—According to Reyes, *H. tiliaceus* is reported to season well.

Natural durability—*H. tiliaceus* is said to be durable under cover but perishable in contact with the ground (Reyes).

Insect attack—Newly felled logs of *H. macrophyllus* are liable to damage by shot-hole borers, while the sapwood is attacked in *H. tiliaceus* by *Acicnemis mansueta* Fst. (Curculionidae).

Preservative treatment—The timbers have not been so far tested for preservative treatment.

Working qualities—Both the timbers are easy to work and finish rather well.

Supply and uses—Only limited supplies of *H. macrophyllus* are available in Assam, where it is mostly used for rafters and posts for house-building. The timber of *H. tiliaceus*, where available, is locally used for light boats, catamarans, toys and occasionally for hut-building. According to Record in the West Indies the deeper coloured heartwood is in demand for furniture and interior work. Reyes mentions it as being used in the Philippines for scabbards, household implements, picture-frames and musical instruments.

Material—

H. macrophyllus – 3289 Chittagong (0·53), 7599 Assam (0·61).
H. tiliaceus – 405 Sundarbans (0·52), 7710 W. Bengal (0·55), 7768 Coimbatore, Madras (0·74).

2. KYDIA Roxb.

A small genus of trees confined to India and Burma. It includes only two species of which one – *K. calycina* Roxb. is described here. *K. glabrescens* Mast – *magan*, *petshat* (Burm.), *kukuha* (Darrang), *subi-asing* (Miri), – is a large tree of Assam and Upper Burma about 30 m. in height and 3 m. in girth, for which no wood specimen was available for study.

Kydia calycina Roxb.—**pula.** *Kukuha* (Asm.), *bothi* (Bhil), *baluma-shaw, dwakbok, dwabote, dwalok, magan, magan-kaji, magap, meikyat, myet-hlwa, petshat, tabo, tayawni* (Burm.), *kukuha* (Darrang), *changne, tabri* (Duff.), *boldo-bak* (Garo), *bosha, buruk* (Gon.), *chourpultea, patha, pola, pothari, pula, puli, pulu* (Hind.), *modon-phang* (Kach.), *kotra* (Kamrup), *bellaka, bende, billu-bhendi* (Kan.), *dieng-jannep, dieng-misri* (Kh.), *wala* (Khond), *bithagonyer* (Kol.), *kubinde* (Kurseong), *sedang-tagla, tagla* (Lep.), *nedunar, velukku, venda* (Mal.), *iliya, ran-bhendi, warang* (Mar.), *arlak-arong, arlakso-arong, parak, starmisri-arong* (Mik.), *barranga, bhoti* (M.P.), *heppaching* (Naga), *bonkopah, bonkopahi* (Nowgong), *kopasiya* (Or.), *pula, puliyan* (Punj.), *olat, puska* (Sant.), *pichola* (Sibs.), *bendi, pula, vallakannu, vendai* (Tam.), *kondapathi, kondapatti, pandiki, pedda-kunji, pedda-potri, potri* (Tel.). A moderate-sized tree attaining in favourable localities a height of 12–15 m. with a clear bole of 6 m. and a girth of over 1 m. *Bark* grey outside, reddish and fibrous inside, peeling off in irregular flakes or long strips, about 6 mm. thick. It occurs all over India and Burma excepting the arid region and is common in the deciduous forests and the sub-Himalayan tract.

Description of the wood

(Pl. 24, 142)

General properties—Sapwood creamy white, wide; heartwood greyish-brown with a purplish tinge, small, but sharply defined; soft, occasionally somewhat harder, light, sometimes sligthly heavier (sp. gr. 0·38–0·56 air-dry); lustrous when quarter-sawn; straight-grained, coarse to medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually distinct, delimited by denser fibrous tissue and a more or less continuous line of soft tissue, occasionally faint, 1–4 per cm. *Pores* moderately large, few to moderately few (3–8 per mm.^{2}) evenly distributed, occasionally less so, being fewer in the middle portion of the growth ring, mostly solitary or in short radial multiples of 2–3, rarely more, sometimes also in clusters, round to oval in outline,

usually open, occasionally plugged with tyloses; vessel lines distinct. *Soft tissues* predominantly apotracheal, indistinct to the naked eye, distinct under the hand lens as fine concentric somewhat irregular or broken lines (3–7 per mm. radially) forming a reticulum with the rays; also round the pores as a faint white border. *Rays* moderately broad to fine, the former distinctly visible to the eye, few and widely spaced; the latter visible only under hand lens, more closely spaced; the larger rays prominent on the radial surface as lustrous flecks up to 2 mm. or slightly more in height, not storied. *Ripple marks*, present 28–35 per cm. rather faint and some what irregular.

Strength—It has been tested only on small scale. It is a moderately strong timber of the same class as or slightly better than *semul*. For strength figures see appendix I.

Seasoning—An easy timber to season, but liable to sapstain and surface discoloration during drying. It should be converted green and stacked in a well ventilated shed.

Natural durability—Not durable in exposed situations but fairly so under cover.

Insect attack—Both logs and converted timber are subject to attack by different types of borers, as a result of which, almost the whole interior of the wood may sometimes be reduced to powder.

Preservative treatment—Not tried, but from its structure and general properties, it would appear to be easily treatable.

Working qualities—It is easy to work, both on machines as well as by hand, giving a good surface.

Supply and uses—Large supplies are available in the east zone comprising Assam, Bihar and W. Bengal. The central, western and south zones could also supply fair quantities while the supplies are limited in the north zone. It is suitable for light packing cases, veneers and plywood and has been tried and found fairly good for match manufacture (boxes as well as splints) and cheap grade pencils. In Burma it is said to be used for ploughs and oars (Rodger), while according to Talbot it is used locally in Madras for house-building, agricultural implements and carving.

Material—

1163 Ahiri (0·53), 1177 Ahiri (0·59), 3154 Saharanpur, U.P. (0·57), 4428 Jaunsar, U.P. (0·53), 5304 Dehra Dun, U.P. (0·55), 5811 Dehra Dun, U.P. (0·51), 6256 Burma (0·49).

3. THESPESIA CORREA

A small genus of trees and shrubs, comprising about six species distributed mainly in tropical Asia, Africa and the Pacific islands but extending also to the

Caribbean. Of the two species occurring in India, *T. populnea* Correa attains tree size and is described here. *T. lampas* (Cav.) Dalz et Gibs. (*Hibiscus lampas* Cav.) – *bonkapash* (Asm.), *bankapas, kakhi* (Hind.), *kaphal-muk* (Nep.), *bankapsi* (Santh.), *kondapathi* (Tel.); is a small shrub occurring throughout India, Burma and Ceylon, chiefly in the deciduous forests.

T. populnea Correa. [**T. populnea** (L) Soland]—**bhendi.** Also commonly known as portia tree or tulip tree. *dumbla, parash, poresh* (Beng.), *bendi, parascha-pipla* (Guj.), *parasipu* (Hind.), *asha, bugari, huvarasi, hoovarasu* (Kan.), *porassu* (Mal.), *bhendi* (Mar.), *suriya* (Sinh.), *kavarachu, porasia, poris, portia, pursa, puvarachu, puvarasam, puvarasu* (Tam.), *gangarari, gangaraya, gangaregu, gangareni* (Tel.). A small to medium-sized tree 6–12 m. in height with a clear bole of 2–2·5 m. and a girth of about half to 1 m. or more.

Bark, grey or greyish-brown, smooth or fissured, fibrous, 3–8 mm. thick. In the Indian region it is quite common in the coastal forests particularly on the west coast, in the Andamans, Bengal, Chittagong, Burma and Ceylon; often cultivated as an avenue tree. It has a wide distribution in the tropics being found in Africa, Malaya, the Philippines, Thailand, Indo-China, East Indies and the Pacific islands and extends even to the West Indies and the Caribbean.

Description of the wood

(Pl. 24, 143)

General properties—Sapwood white, with a pale yellowish or pinkish tinge, darkening on exposure, about 1–2 cm. wide; heartwood reddish-brown to chocolate or even purplish-brown with darker streaks, sharply defined; moderately hard to hard; moderately heavy to heavy (sp. gr. 0·55–0·89 air-dry); rather dull; straight to somewhat interlocked-grained, even and medium-textured with a smooth feel.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, occasionally demarcated by denser fibrous tissue and a faint and somewhat discontinuous line of soft tissue, 1–5 per cm. *Pores* medium-sized to small, distinct to scarcely visible to the eye, clearly visible under a lens, few to moderately few (2–10 per $mm.^2$), evenly to somewhat unevenly distributed, mostly solitary or in radial multiples of 2–3 or more, occasionally in clusters, round to oval in outline, mostly plugged with dark red gum; vessel lines distinct but usually filled with gum giving a smooth appearance. *Soft tissues* indistinct to the eye, visible under lens, diffuse to diffuse-aggregate and in fine closely-spaced interrupted tangential lines, forming an irregular reticulum with the rays. *Rays* mostly fine, occasionally moderately broad, indistinct to just visible to the eye, distinct under lens, evenly spaced, fairly wide apart forming an inconspicuous fleck on the radial surface usually not exceeding 0·5 mm. in height rarely up to 1 mm., occasionally storied. *Ripple marks* usually present,

fairly distinct to just visible to the eye, rather faint and irregular about 32–40 cm. As a rule the ripple marks are more distinct in sapwood and straighter-grained timber.

Strength—The timber has been tested only on a small scale. For Strength figures please see appendix I.

Seasoning—Not a difficult timber to season if ordinary precautions in stacking and against too rapid drying are taken.

Natural durability—The timber is reported to be durable.

Insect attack—None of the specimens in the F.R.I. collections or the logs examined showed any insect damage.

Working qualities—Not difficult to work, giving smooth and taking a high polish.

Supply and uses—Only limited supplies are available, mostly from the west coast forests of Bombay and Mysore. It is a timber of great local utility being used for agricultural implements, furniture, cart and carriage making (for wheels, shafts and spokes) and boat building particularly for knees and joints. It has proved to be a good timber for helves and tool handles and is used even for gun-stocks in south India. It is also said to be used for bowls, clubs and paddles in the Carolines.

Material—

1050 Gujarat (0·68), 2470 Andamans (0·54), 2488 Calcutta (0·56), 7580 Bombay (0·68), 7709 W. Bengal (0·88), 7744 Kolaba, Bombay (0·67).

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K. RAMESH RAO.

17. BOMBACACEAE

The *Bombacaceae*, which is included by some taxonomists under the *Malvaceae*, consists of about 20–25 genera and approximately 150 species. Mostly trees, the majority of the genera are distributed in the American tropics while about half a dozen or so occur in the Indo-Malayan region.

The economic importance of the family is mainly on account of its being the source of the well-known balsa wood and kapok floss of commerce. A commercially useful floss similar to kapok from *Eriodendron anfractuosusm* DC. [*Ceiba pebtandra* (L.) Gaertn.] is also obtained from the capsules of *Bombax malabaricum* DC. and *B. insigne* Wall. The bark of the former yields a gum used in indigenous medicine and also as a substitute for gum tragacanth. The well known 'durian' or civet-cat fruit of Burma and Malaya is produced by *Durio zibethinus* DC. which is often cultivated. The leaves, bark, roots and fruits of a number of species are used in indigenous medicine and for other purposes. Some genera like *Cavanillesia*, *Ceiba* and *Ochroma* produce exceptionally light woods. At the other extreme is the South American *Aguiaria* which furnishes a very hard and very heavy (sp. gr. 1·14 air-dry) timber, used locally for constructional purposes. *Bombax* and *Cullenia* provide timbers of some commercial importance.

The family is represented in the Indian region by 5 genera, all of which consist of large trees. Though now found growing in a wild state, certain authorities are of the opinion that some of them at least might have been introduced long ago. Besides these five, the South American genus *Ochroma*, which has been planted with some success in India and Ceylon, is also described here on account of its economic importance.

The woods range in colour from creamy or greyish-white in *Bombax*, *Eriodendron* and *Ochroma* to pinkish or light reddish-brown in *Cullenia*, *Durio* and *Neesia*, and are usually soft and extremely light to light in the former and relatively harder and light to moderately heavy in the latter. They are somewhat similar in structure, being featured anatomically by large to moderately large, scanty pores, and predominantly apotracheal parenchyma which is mostly reticulate, in fine more or less interrupted tangential lines. These may be very closely spaced as in *Bombax* and *Eriodendron*, or form the bulk of the ground mass as in *Ochroma* or spaced a little further apart as in *Cullenia*, *Durio* and *Neesia* of the tribe *Durioneae*. Parenchyma is distinctly storied, in *Bombax* and *Eriodendron* giving rise to ripple marks and secondary seriation. Rays broad to fine, the latter tending to be storied in woods with ripple marks. Anatomically the *Durioneae* constitute a homogeneous group, distinct from the others. The different members of the *Durioneae* cannot always be distinguished from one

another even under the microscope. However, it is often possible to separate the other genera as given below.

Key to the genera

1.	Ripple marks and secondary seriation usually present	2
1.	Ripple marks and secondary seriation absent ...	3
2.	Concentric bands of parenchyma often present, delimiting growth rings, reticulate pattern poorly defined	*Eriodendron*
2.	Concentric bands of parenchyma delimiting growth rings absent, reticulate pattern always distinct	*Bombax*
3.	Soft tissues not clear. Wood white, extremely soft and extremely light	*Ochroma*
3.	Soft tissues distinct, visible under lens as fine interrupted lines forming a reticulum with rays. Wood light reddish-brown, moderately hard and light to moderately heavy	*Cullenia* *Durio* *Neesia*

1. BOMBAX L.

A tropical genus containing over 40 species ; the majority are in central and South America, while a few occur in Africa and South-East Asia. In the Indian region five are known to grow. All are large trees, excepting *B. scopulorum* Dunn, which is a small tree of the forests of Travancore. They grow from sea-level to over 900 m. elevation, and are found mostly in the deciduous and mixed forests and also to some extent in evergreen forests. *B. malabaricum* DC. and *B. insigne* Wall. occur in India proper, while *B. cambodiense* Pierre and *B. anceps* Pierre are confined only to upper Burma and Cambodia.

The timbers of the different species are similar in appearance, anatomical structure and physical properties and therefore cannot be distinguished from one another. They are usually creamy white to greyish-brown, soft and light. *B. malabaricum* and *B. insigne* are commercially important and are dealt with here. A single specimen of *B. cambodiense* examined was found to be in no way different from *B. malabaricum* and *B. insigne*.

1. **B. insigne** Wall. (**Salmalia insignis** Schott and Endl.)—**semul.** *didu* (Andamans), *semul, tula* (Beng.), *didu, didok, taung-letpan* (Burm.), *dhumboil* (Cachar), *anphang-thing* (Kuki), *pang* (Lush.), *sait* (Magh), *kalilavu*

(Mal.), *tera* (Manipur), *kal-ilavu* (Tam.). A large deciduous tree with a straight cylindrical bole often buttressed. In the evergreen forests of Tavoy it attains a height of 24 m. clear bole and a girth of about 2 m. In the Andaman islands it grows to a much larger size, up to 4 or 5 m. in girth. *Bark* usually dark grey, vertically furrowed, without any prickles, up to 2·5 cm. thick on the main bole, but much thinner and covered with prickles on the branches.

In India proper, the tree is confined to the Western Ghats and Assam, but also occurs in Chittagong in East Pakistan. It is fairly common in the Andamans and Burma and extends to the Malay Peninsula.

Description of the wood—See below.

2. **B. malabaricum** DC. [**Salmalia malabarica** (DC.) Schott and Endl.]—**semul.** *himila, himolu, himulu simolu* (Asm.), *simal, simul, tula* (Beng.), *khatsaweri* (Bhil), *letpan* (Burm.), *shimal* (Garhwal), *bolchu* (Garo), *bargu, wallaiki* (Gon.), *sawar* (Guj.), *semul, semur* (Hind.), *bonju-phang, ponju-phang* (Kach.), *shimlo* (Kamrup), *burla, buruga, sauri* (Kan.), *dieng-kymphad, dieng-syr-ah* (Kh.), *kamba* (Khond), *del* (Kol.), *an-phang, phunchang* (Kuki), *sunglu, tunglu* (Lep.), *ilavu* (Mal.), *saur, savar, sayar* (Mar.), *simla* (Mechi), *pharkong-arong* (Mik.), *singi-asing* (Miri), *bouro, buroh* (Or.), *simbal, shirlan* (Punj.) *kati-imbul* (Sinh.), *dieng-kya* (Synteng), *illavam, parutte, pula* (Tam.), *buraga, burga, burgu* (Tel.). A large deciduous tree over 30 m. in height and 3 m. in girth with a clear bole of 24–30 m. often with huge buttresses, which may be as much as 4·5–6 m. in height. Under favourable conditions it grows to an enormous size ; one tree 59 m. in height and 4·5 m. in girth has been reported from Coorg by Pearson and Brown. On poor soil and higher elevations, however, it is usually stunted. *Bark* grey and covered with large conical prickles in young trees, but in older trees, without any prickles, and fissured vertically ; outer bark fleshy and soft, inner fibrous, up to 2·5 cm. in thickness.

Widely distributed throughout India and Burma, except in very arid tracts, ascending to over 1,000 m. Although it has a very wide range it is nowhere very common, usually occurring scattered in mixed deciduous forests. Occasionally it tends to be gregarious on alluvial soils near river banks.

Description of the wood—See below.

Description of the wood

(*Bombax insigne* and *B. malabaricum*)

(Pl. **24**, 144 and Pl. **25**, 145)

General properties—Wood creamy-white when freshly cut, becoming pale yellowish-brown to greyish-brown on exposure ; usually no colour difference between sapwood and heartwood, but occasionally some logs show a darker

coloured pinkish-brown to reddish-brown centre ; very soft to soft ; very light to light (sp. gr. 0·25–0·50 air-dry), often lustrous showing silver effect on radial surface ; coarse but even-textured.

Gross structure—Both are diffuse-porous woods. *Growth rings* not always distinct to the eye, but clearly visible under hand lens, delimited by the slightly denser late wood and closely spaced bands of soft tissues, usually less than 2 per cm. in *B. malabaricum*, but up to 8 or more per cm. in *B. insigne*. *Pores* very large to large, clearly visible to the eye, very few to few (less than 1 to 4 per mm.^{2}), usually more or less evenly distributed, with little difference in size throughout the growth ring, mostly solitary or in short radial multiples of 2–3, rarely more, oval in outline, usually open or partly filled with tyloses ; vessel lines conspicuous on the longitudinal surfaces, vessel elements being individually distinct 20–25 per cm. *Soft tissues* or *parenchyma*, predominantly apotracheal, visible only under the lens appearing as fine, closely-spaced, somewhat interrupted tangential lines, forming a reticulum with the rays ; lines of soft tissue about the same width as or wider than the fibre layers, 10–15 per mm. and often extending across two or more rays. *Rays* broad to fine, widely spaced; the broader rays very few but prominent to the eye, 1–5 mm. or occasionally more in height, forming a conspicuous lustrous fleck on the radial surface ; the narrower or fine rays few, just visible or indistict to the eye, distinct only under lens, interspersed with broader rays sometimes tending to be storied. *Ripple marks* usually present, distinct to just visible to the eye, but sometimes less so under the lens, 20–22 per cm. Secondary seriation due to storied parenchyma usually distinct under lens.

Strength—Both the species have been tested for strength at Dehra Dun. For strength figures please see appendix I.

Seasoning—Very easy to season but liable to sap stain and discoloration, if kept in log form ; should be converted green or soon after felling and immediately stacked in the open under cover, or kiln dried.

Natural durability—Not at all durable, when used in exposed situations, with an average life of about a year in the graveyard tests at Dehra Dun, but said to be very durable under water.

Insect and fungus attack—Standing trees of *B. malabaricum* may be infested by a number of insects such as longhorn beetles, defoliators and the *semul* shoot-borer, the last being a common pest in plantations. Logs are subject to serious damage by longhorn beetles (Cerambycideae) and weevils (Curculionideae), while minor loss may be caused by pin-hole and shot-hole borers (Platypodideae and Scolytideae). Damage due to lyctus and powder-post beetles (Bostrychideae) is very common in converted timber and finished articles. Logs and converted timber of *B. insigne* are also equally susceptible to insect

damage. The timber is liable to sap stain and various kinds of rot due to fungus attack.

Preservative treatment—Only *B. malabaricum* has been tested. It is very easily treatable with preservatives, penetration being complete. Treated timber is moderately durable in the open but lasts longer under cover.

Working qualities—The timber of both the species is easy to saw and work. It peels well without any preliminary treatment. On account of the coarse texture and prominent vessel lines, it absorbs too much paint and varnish. A good finish is, therefore, difficult but may be obtained if a filler is used. It glues well.

Supply and uses—Assam and Bengal have the largest supplies of *B. malabaricum* in India. It is also availble in Uttar Pradesh, Madras, Bombay and Travancore-Cochin (Kerala) in large quantities, but the demand is always more than the supply. The chief sources of *B. insigne* are the Andamans and Burma where the sawn timber is available in large sizes. It is also available in Assam and the west coast. The timber of the two species is very similar and is extensively used by the match industry for boxes as well as splints. It produces a useful plywood where strength is not so important. 'Compreg' from *semul* has proved suitable for bosshead of air screw blades. Among its other uses are packing cases, dug-outs, drums, fishing floats toys and cheap grade pencils.

Material—

B. insigne – 2215 Andamans (0·50), 5246 Andamans (0·41), 5247 Andamans (0·38), 5248 Andamans (0·45), 5686 Tharrawady, Burma (0·45), 5833 Andamans (0·37), 5997 Pegu Yoma, Burma (0·29), 6480 Burma (0·41), 6841 Burma (0·41), 7745 Travancore (0·35).

B. malabaricum – 201 Mandla (0·46), 466 Ajmere (0·36), 679 Darjeeling terai (0·37), 1117 Chanda (0·50), 1295 (0·50), 1297 (0·42), 1432 Assam (0·31), 1961 Chittagong (0·35), 2323 Darjeeling terai (0·26), 3117 Burma (0·35), 5301 Burma (0·34), 6842 Burma (0·44), 7179 Dehra Dun (0·28), 7339 Bengal (0·25), 7436 Gujerat (0·41), 7519 Bengal (0·33), 7619 Bombay (0·35), 7707 Assam (0·34), 7708 Assam (0·35), 7749 Bombay (0·43), 7756 Madras (0·38), 7857 Orissa (0·48).

2. CULLENIA WIGHT.

A monotypic genus of large trees, confined only to the south-west corner of India, and Ceylon.

C. excelsa Wight.—**karani.** Commonly known as wild durian, *chakkamullan, kar-aini, mulluchakka, vedipila, vetipla* (Mal.), *katu-boda, mullu-plaka* (Sinh.), *ainipla, karani, karayani, korangupilavu, polavu, vedipila* (Tam.). A medium-sized to large evergreen tree, pyramidal in shape, reaching a height of 30 m. with a straight, clear bole up to 18 m. in height. The old trees may attain a girth of over 3 m. but are often buttressed and fluted. *Bark* greyish-white, smooth and thick.

It is fairly common in the moist forests of Western Ghats, Coorg, Wynaad, Malabar, Anamalai hills, and Travancore and is found at an elevation of 600–1800 m. It also grows in Ceylon.

Description of the wood

(Pl. 25, 146)

General properties—Wood grey to brown with a pinkish tinge darkening with age ; no sharp distinction between heartwood and sapwood, but occasionally some logs may show a pinkish shade gradually deepening towards the centre ; moderately hard ; light to moderately heavy (sp. gr. 0·51–0·66 air-dry), occasionally somewhat lustrous, straight-grained ; even and medium-textured.

Gross structure—A diffuse porous wood. *Growth rings* usually indistinct, both to the naked eye and under the hand lens, occasionally faintly visible, delimited by the somewhat denser latewood. *Pores* large to moderately large, visible to the naked eye, distinct under hand lens, more or less uniform in size throughout the growth ring, very few to moderately few (1–7 per mm.^{2}), mostly solitary or in radial multiples of 2–3, rarely 4 or more, oval in outline, usually open, occasionally filled with reddish-brown deposits ; vessel lines straight, distincitly visible along the grain but not conspicuous. *Soft tissues* or *parenchyma* predominantly apotracheal, indistinct under hand lens, appearing as light-brown, fine concentric often interrupted lines, about 3–8, usually 5 per mm. radially, forming a reticulum with the rays, occasionally tending to be diffuse. *Rays* moderately broad to very fine ; the former distinctly visible to the eye, few widely spaced usually 1–3 mm. in height, rarely up to 5 mm. forming a fairly distinct reddish-brown fleck on the radial surface, against the lighter coloured and somewhat lustrous back ground ; the latter not visible to the eye but distinct under a lens, somewhat closely spaced, interspersed with the broader rays, usually not storied, but rarely with just a suggestion of irregular storied arrangement. *Ripple marks* absent, rarely a mere suggestion due to the finer rays, tending to be irregularly storied.

Strength—For strength figures please see appendix I.

Seasoning—Kiln seasoning gives best results. If kiln seasoning is not practicable, the logs should be converted absolutely green and open-stacked providing the maximum ventilation.

Natural durability—Not durable in the open, with an average life of about a year and half in graveyard tests at Dehra Dun, but fairly so under cover.

Insect and fungus attack—Logs are subject to damage by pin-hole borers, shot-hole borers and ambrosia beetles. Converted timber appears to be less susceptible to attack as none of the specimens in the Dehra Dun collection showed any insect damage. It is subject to discoloration and rapid deterioration in log form due to fungal attack.

Preservative treatment—Easily treatable, with complete penetration.

Working qualities—Very easy to saw and split ; can be worked with great ease both by hand and machines.

Supply and uses—Moderate supplies are available from the evergreen forests of the Western Ghats in the south zone. It is a good packing case timber and is extensively used as planks for furniture making. It peels well and yields a good plywood.

Material—

4604 Travancore (0·51), 6140 Olavakkot, Madras (0·56), 7714 Travancore (0·55), 7806 Coimbatore (0·66), 7955 Madras (0·54).

3. DURIO L.

A small tropical genus of trees, consisting of about 15 species found mostly in Malaya and the East Indies. Only one species *Durio zibethinus* DC. is known to occur in Burma in the Indian region.

The timbers of the different species are indistinguishable being similar in appearance and properties and are all known as durian-daun in Malaya. They are usually pinkish to reddish-brown soft to moderately hard, light to moderately heavy, medium to somewhat coarse-textured and straight-grained. Only one species *Durio zibethinus* DC. comes within the scope of this book.

D. zibethinus DC.—**durian.** *du-yin* (Burm.) *durian daun* (Malaya). A medium-sized to large evergreen tree about 12–30 m. high, with a girth of 1–2·5 m. or more. *Bark* grey and usually smooth with few vertical clefts and horizontal wrinkles.

Among all the species of *Durio*, this has the widest distribution occurring in Burma, Malaya and the East Indies. It grows wild in lower Tenasserim, and is often cultivated for its fruit in upper Tenasserim as also in Malaya and Borneo. Attempts have been made to cultivate the plant in Ceylon and several parts of India. It has been successfully grown to some extent in parts of west coast and lower elevations of Nilgiris.

Description of the wood

(Pl. 25, 147)

General properties—No distinction in heartwood and sapwood in the specimen examined, though Desch describes the sapwood as white and sharply defined ; wood pinkish-grey to pinkish-brown or pale reddish-brown, darkening on exposure ; soft to moderately hard ; light to moderately heavy (sp. gr. 0·54 air-dry); somewhat lustrous, fairly straight-grained ; even and medium to coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, occasionally demarcated by slightly denser latewood. *Pores* usually large to moderately large, clearly visible to the eye, often with little difference in size throughout the growth ring, few to moderately few (2–6 per mm.^{2}), mostly solitary or in radial multiples of 2 to 3, rarely more, round to oval in outline, usually open, occasionally filled with reddish-brown deposits ; vessel lines straight, fairly prominent. *Soft tissues* or *parenchyma* predominantly apotracheal not visible or indistinct to the eye, but distinct under lens as fine broken irregular lines, about 5–9 per mm. radially, forming a reticulum with the rays. *Rays* moderately broad to very fine ; the moderately broad rays visible to the eye, very few and widely spaced, usually up to 2 mm. rarely more in height, forming a distinct brown fleck on the radial surface ; the fine rays visible only under hand lens, somewhat closely spaced, interspersed with the broader rays and without any storied arrangement. *Ripple marks* absent.

No specific information regarding the strength and other properties of *Durio zibethinus* is available. However, Brown Murdoch gives the coefficient of transverse strength of *Durio* spp. from Malaya as 6·00 tons per sq. inch, while according to Foxworthy, all the Malayan species appear to be somewhat difficult to season, being liable to crack and shrinking badly during drying. The timber is also said to be not durable in exposed situations, being subject to fungus attack discoloration and insect damage. It is not of much commercial importance even in Malaya where it is reported to be used for plywood, clog-manufacture, planking and sometimes for furniture and constructional work in unexposed, parts of huts.

Material—

5074 Thaungyin, Burma (0·54).

4. ERIODENDRON DC.

(*Ceiba* Gaertn.)

This is a tropical genus of large trees containing about 15 species. The majority are confined to the American tropics, mostly Mexico and Brazil, only one or two occurring in tropical Africa and Asia. The most widely distributed

species of commercial importance is *Eriodendron anfractuosum* DC. [*Ceiba pentandra* (L) Gaertn.] the well-known kapok tree, which is described here.

E. anfractuosum DC. [**Ceiba pentandra** (L) Gaertn.]—**kapok**. *schwet-semul* (Beng.), *letpan, thinbaw* (Burm.), *hatian, katan, safed simal, semibal* (Hind.), *biliburuga, dudi mara* (Kan), *mull-ilavu, panji, panji-ilavu, panya, seemapoola* (Mal.), *pandhari savar, shamieula* (Mar.), *pulun imbul* (Sinh.), *ilavum, panji* (Tam.), *kadami, pur, tella buruga* (Tel.). A medium-sized to to large deciduous tree with branches in horizontal whorls. In the American tropics, it grows into a massive tree, 24–30 m. high, with a cylindrical stem and thick buttresses. It is a tree of the open with a large crown, having a spread of about 150 ft. (Record). In India it is only a moderate-sized tree with a clear bole of 12 m. Under favourable conditions it has been reported to grow very fast reaching some 9 m. in height at the end of 3–4 years. In young trees the bark on the main trunk as well as the branches is usually covered with conical prickles which disappear with age.

It has an extensive distribution in the tropics, being indigenous to Malaya, Africa and South America. It is also found in the Andamans. According to some authorities, there are more than one variety in this species. It is not indigenous in India but has become naturalized on the west coast and elsewhere. It grows in a wild or semi-wild state from sea-level up to an altitude of 900 m., but is at its best at elevations less than 450 m.

Description of the wood

(Pl. 25, 148)

General properties—Wood greyish-white, oatmeal or greyish-brown in colour ; without any sharp distinction into heartwood and sapwood ; extremely soft to soft ; extremely light to light (sp. gr. 0·14–0·28 air-dry), dull to somewhat lustrous, some times with rough feel ; straight-grained ; even and coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct to fairly distinct to the eye, distinct under hand lens, usually delimited by a continuous band of soft tissue, less than 1 to 3 per cm. *Pores* large to moderately large, distinctly visible to the eye, more or less uniform in size throughout the growth ring, very few to few (1–5 per $mm.^2$), evenly distributed, mostly solitary or in radial multiples of two or more, oval in outline, usually filled with tyloses ; vessel lines distinct, but not so prominent as in *semul*. *Soft tissues* or *parenchyma* predominantly apotracheal, indistinct to fairly distinct, showing an irregular, poorly defined reticulate pattern ; also present as concentric bands usually delimiting growth rings. *Rays* moderately broad to very fine, rather widely spaced ; the former distinct to the eye, usually 1–3, occasionally up to 4 mm. or more in height showing up as flecks on the radial surface, interspersed with fine rays, visible only with a lens and occasionally tending to be storied.

Ripple marks present, but poorly defined, just visible to the eye, about 24–28 per cm. Secondary seriation due to storied parenchyma clearly visible under hand lens.

Strength—Gamble gives the value of P (coefficeint of transverse strength) as 400 and weight of wood at 30 lb.

Seasoning—Not possible to season in the log. Quick conversion followed by proper air seasoning or kiln drying may give clean dry timber.

Natural durability—Not durable. Almost certain to discolour and very likely to rot if kept long in log form.

Insect attack—Easily attacked by insects.

Preservative treatment—No reliable information is available.

Working qualities—Very soft and easy to work.

Supply and uses—It is nowhere available in India in commercial quantities. But if a demand arose for it, its cultivation might easily be extended. The wood has been reported to be of poor quality and inferior to *semul*. However, being very light and soft, it appears to be suitable for dug-outs, canoes, platters and toys. Schneider mentions it as being used in the Philippines for fish-nets and live fence posts. According to Record other suggested uses are core-stock for veneers, slack cooperage, packing cases and boxes. Timber from fast-grown trees is extremely light (sp. gr. 0·15–0·20 air-dry) and if properly selected and carefully seasoned may serve as a substitute for balsa

Material—

7736 Travancore (0·14), 7757 Madras (0·28), 7823 Madras (0·18), 7824 Madras (0·18).

5. NEESIA BLUME

A tropical genus of trees confined mostly to Malaya. Of the seven species included in the genus only one has been recorded in Burma and is considered here. According to Desch the timbers of the different species are not distinguishable and are all known under the name *apa-apa*.

N. synandra Mast.—*apa-apa* (Malaya). A tall straight tree 20–30 m. high, found in Mergui in Burma and Malaya peninsula.

Description of the wood

(Pl. 25, 149)

General properties—Wood light brown with a pinkish or reddish tinge (heartwood only examined). According to Desch in *N. altissima* Bl. the sapwood is "pale yellow, sharply defined about 1½ inches in width". Wood soft, light (sp. gr. 0·49 air-dry) ; straight-grained, medium to coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, occasionally faintly delimited by somewhat denser fibres. *Pores* large to moderately large, distinctly visible to the eye, more or less of the same size throughout the growth ring, very few to few (2–5 per mm.^{2}), evenly distributed, mostly solitary or in short radial multiples of 2–3, rarely more, round to oval in outline, usually open, occasionally filled with orange-brown gummy deposits ; vessel lines straight, fairly prominent. *Soft tissues* indistinct to the eye but visible under lens as fine irregular broken lines about 4–7 per mm. radially, forming a reticulum with the rays. *Rays* moderately broad to fine, just visible to the eye, distinct under lens, rather closely spaced, usually less than 1 mm. in height showing up as distinct brown flecks on the radial surface, not storied.

No data regarding strength, working qualities and other properties of the timber are available. However, from the close similarity to *Cullenia* and *Durio* it would appear to be suitable for plywood and planking for furniture.

Material—

6578 Burma (0·49).

6. OCHROMA Sw.

A tropical genus of extremely light and softwooded trees, found growing in their natural state in tropical South America and the West Indies. The genus is not represented in the Indian region but is included in this book firstly on account of its commercial importance as yielding a timber of great strategic value and secondly because of the fairly successful attempts that have recently been made to grow it in plantations in some parts of India and Ceylon. Though some authors recognize about a dozen species within the genus, according to others most of these may for all practical purposes be considered as only forms or varieties of a single species *Ochroma lagopus* Sw.

Ochroma lagopus Sw. [**Ochroma pyramidale** (Cav.) Urban]—**balsa.** An extremely fast growing tree, reaching under favourable conditions a height of 18 m. or more with a clear bole of 6–9 m. and a girth of 1–2 m. in 6–8 years. It is essentially a tree of the moist hot tropics, growing from sea-level up to 600 m. elevation. Though not indigenous to India, it has been successfully grown in plantations at Kannoth and Top-slip in the Wynaad and South Coimbatore Forest Divisions of Madras, and may do well in other areas including the Andamans. It is also reported to be cultivated extensively in Ceylon.

Description of the wood

(Pl. 25, 150)

General properties—Wood (only sapwood examined) almost white to oatmeal coloured with a slight pinkish or greyish tinge ; heartwood when present said

to be pale brown to reddish-brown (Record) ; extremely soft, easily indented with the finger nail, extremely light (sp. gr. 0·12 to 0·15 air-dry) but reported to be considerably heavier (sp. gr. up to 0·40) under certain adverse conditions, straight-grained, medium to coarse-textured, somewhat lustrous with a smooth velvetly feel. It is extremely buoyant and resilient and has remarkable heat and sound insulating properties.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct but occasionally delimited by somewhat crowded vessels, less than one ring per 3 cm. in fast grown material. *Pores* large to moderately large, very few to few (1–5 per mm. ^{2}), usually evenly distributed but some times with a tendency to crowding especially near growth marks, mostly solitary or in short radial multiples of 2–3, rarely more, oval in outline and open ; vessel lines distinct, but not very conspicuous. *Soft tissues* abundant, forming bulk of the ground tissue, reticulate, but indistinct and not distinguishable from fibres even under hand lens owing to the latter being extremely thin-walled. *Rays* broad to moderately broad, distinct to the eye, few and wide apart, evenly spaced and not storied.

Strength—It is the lightest, weakest and softest of all commercial timbers, but weight for weight is reported to be stronger than even sitka spruce. Curiously enough the so-called heartwood has been found to be only half as strong as the sapwood which is the commercial product. For strength figures of Indian balsa (sapwood) please see appendix I.

Seasoning—As it is apt to shrink considerably, balsa is reported to be rather difficult to season. Kiln drying has been found to be the best. It can also be satisfactorily air-seasoned by quick conversion and end-stacking the boards against a horizontal support.

Natural durability—Not at all durable. It decays quickly in the presence of moisture.

Insect attack—Liable to borer attack.

Preservative treatment—Adequate protection against decay in contact with moisture is provided by simple water proofing treatment such as impregnation with hot melted paraffin or suitable water repellant preservatives.

Working qualities—Easy to work with sharp thin-edged tools on which there is practically no blunting effect. It is easy to screw and nail without any splitting, but does not hold them well under strain. It glues exceedingly well and is best joined this way.

Supply and uses—The chief sources of supply are in tropical South America particularly Ecuador, while some of the central American States and the West Indies also produce it in commercial quantities. In India it is not yet produced on a large scale and the demand has to be met from imports. Balsa is chiefly used where extreme lightness and special insulating properties are called for.

During the last two wars it came into prominence as a timber of great strategic value being much in demand by the Navy and the Air Force. The lightest grade timber (sp. gr. 0·12) is required for aircraft, the Navy requirements being met by slightly heavier timber (sp. gr. 0·18). It is used by the Navy for rafts, floats, lifebuoys and other life-saving equipment, while its chief use in aircraft is for corestock of sandwich material used in the construction of Mosquito Bombers. Another important use is as insulating material particularlly for refrigeration trucks and cold storage rooms. It is also used for sound deadening and cushioning heavy machinery for preventing transmission of vibrations in buildings. Other uses are for novelties, toys, hat blocks and model plane kits. The last have become so popular that a single factory in England is at present using as much as a million cu. ft. per year for these toy kits.

Material—

7750 S. Coimbatore (0·12), 8033 Mysore (0·15).

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K. RAMESH RAO.

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18. STERCULIACEAE

The family *Sterculiaceae* is mainly tropical and sub-tropical and comprises approximately 50 genera and about 700 species of trees, shrubs, climbers and herbs having a wide distribution. It has received considerable attention from systematists as well as wood anatomists. The two African genera *Mansonia* and *Triplochiton* have been placed by some botanists in a separate family – the *Triplochitonaceae*. Others consider the section *Buettnerioideae* – which includes besides these two genera, *Eriolaena*, *Helicteres* and *Pterospermum* among those described here – as a distinct family the *Buettneriaceae*.

The economic importance of the family is mainly due to the well-known commercial product, cocoa or chocolate, which is obtained from the seeds of the South American plant – *Theobroma cacao* L. The nuts of the African species *Cola acuminata* Schott. and Endl. are also of some commercial importance as they contain caffein. On account of their stimulating properties, cola nuts are said to constitute a staple article in negro diet and form a principal item of trade in West Africa. Seeds of some species of *Sterculia*, chiefly *S. foetida* L. and *S. urens* Roxb. are often roasted and eaten, while the inner bark of *S. villosa* Roxb., *S. urens*, *Helicteres isora* L. and *Abroma augusta* L. yields a good fibre suitable for making ropes and coarse canvas. *Sterculia urens* trees are often tapped for the gum – known as "katira" which closely resembles gum-tragacanth and is used as a substitute for it. A few others like species of *Melochia* and *Dombeya* are frequently grown in gardens as ornamental plants.

The *Sterculiaceae* are not very important from the point of view of timber. The best known timbers of more than local importance are the West African obeche (*Triplocheton scleroxylon* K. Schum.) and mansonia or pruno (*Mansonia altissima* A. Chev.), which are often exported to the United Kingdom. The former is a soft, light, easily worked timber used for interior joinery, veneers, core-stock for plywood and furniture, while the latter is a handsome timber resembling walnut and is suitable for high-class furniture and cabinet making. Timbers of some importance in the Indo-Malayan region are also furnished by *Heritiera*, *Pterospermum* and *Sterculia*.

The family is represented in the Indian region by 12 or 13 genera of which about 9 or so are woody. Wood specimens were available for study for 6 genera, which are described here. Among those not represented in the wood collection at Dehra Dun are *Leptonychia glabra* Turcz a small tree of the Western Ghats and *Reevesia* Lindl. a genus of small trees occurring in the eastern Himalayas. *Buettneria* Linn. is a genus of woody climbers of which four species occur in the Indian region, chiefly in Sikkim, eastern Himalayas,

Burma and the Andamans. *Abroma augusta* L. though naturalized in several parts of India is only doubtfully indigenous while *Guazuma tomentosa* H.B. & Kunth., *Melochia velutina* Bedd. and *Kleinhovia hospita* L. are introduced trees frequently cultivated and planted in gardens.

The woods exhibit wide variation in their colour, hardness, weight and other physical properties as well as in their gross anatomical structure. It is therefore usually possible to distinguish the different genera without recourse to microscopic study, while in some cases even specific identification is not very difficult. The colour varies from pale yellowish-white in *Helicteres* and most species of *Sterculia*, through intermediate shades of greyish or light reddish-brown in *Pterospermum* and *Mansonia* to brick red or deep reddish-brown in *Eriolaena* and *Heritiera*. As regards other physical properties, they vary from extremely soft to very hard, extremely light to very heavy (sp. gr. 0·16–1·10 air-dry), dull to rather lustrous and coarse to very fine-textured. The woods are usually diffuse-porous with occasional semi-ring-porous tendency in *Helicteres*. Pores large and rather few in *Sterculia* to very small and numerous in *Helicteres* and *Mansonia* (in part) with intermediate sizes predominating in other genera, mostly solitary and in radial multiples of 2–3 or more, rarely in clusters, usually open but filled with reddish-brown gummy deposits in *Heritiera* and tyloses in some species of *Sterculia*. Soft tissues or parenchyma predominantly apotracheal in *Helicteres, Heritiera, Mansonia, Pterospermum* and *Sterculia* (in part), occurring as fine, closely spaced, interrupted or broken tangential lines, forming a net-like structure visible only under the lens, sometimes tending to be diffuse and rather indistinct ; in broad wavy or straight tangential bands in some species of *Sterculia* and predominantly paratracheal in *Eriolaena* and some *Sterculia* spp. forming distinct sheaths or eyelets round the pores, occasionally aliform confluent and connecting adjacent pores by short wavy or straight tangential lines ; also in more or less continuous lines or layers delimiting the growth rings as in *Eriolaena* and to some extent in *Heritiera, Mansonia* and *Sterculia*. Rays usually of two distinct sizes in *Sterculia*, broad and fine, the former clearly visible to rather prominent to the eye, the largest of about the same width as the pores, not storied, the latter just visible and sometimes indistinct even under the lens, often indistinctly storied or tending to be storied giving rise to faint and somewhat irregular ripple marks. In all the remaining genera the rays mostly medium-sized to fine, usually storied except in *Helicteres*, giving rise to fairly distinct ripple marks. Resin canals of the traumatic type, arranged in short or long tangential bands, occasionally present in *Sterculia* and *Heritiera*.

Key to the genera

1. Pores very small, very numerous, just visible under the lens. Wood fine to very fine-textured 2

1. Pores large to medium-sized, few to moderately few, clearly visible to the eye. Wood medium to coarse-textured 3
   2. Ripple marks present. Wood very hard, very heavy, often scented ... ... *Mansonia* (*M. gagei*)
   2. Ripple marks absent. Wood moderately hard, moderately heavy, without any scent ... *Helicteres*
3. Rays broad, prominent to the eye. Wood usually soft, light and coarse-textured ... ... *Sterculia*
3. Rays medium to fine, indistinct or just visible to the eye. Wood moderately hard to very hard, moderately heavy to very heavy and medium-textured ... 4
   4. Soft tissues predominantly paratracheal in narrow vasicentric sheaths or eyelets round the pores, or join two or more adjacent pores by short wavy tangential bands ... ... *Eriolaena*
   4. Soft tissues predominantly apotracheal in fine, closely spaced interrupted tangential lines forming a distinct to somewhat indistinct net-like structure 5
5. Ripple marks very distinct, prominent to the eye, 20–24 per cm. Wood usually yellowish to greyish-brown ... *Mansonia* (*M. dipikae*)
5. Ripple marks fairly distinct to faint and somewhat indistinct, 30–40 per cm. Wood pinkish-grey to reddish-brown 6
   6. Wood usually very hard, very heavy and dark reddish-brown ... ... *Heritiera*
   6. Wood usually moderately hard, moderately heavy, and pinkish-grey to light reddish-brown ... *Pterospermum*

1. ERIOLAENA DC.

A tropical genus of 7–8 species of trees distributed in the Indo-Malayan region. Six or seven species occur in the Indian region of which five are described here. The woods of the different species studied are similar in structure and properties and are indistinguishable from one another.

1. **E. candollei** Wall.—salmon wood, swani. *dwani, petwun, swani, tayaw-ywetwaing* (Burm.), *hadang, kadegi* (Kan.), *bothi, bute* (Mar.), *kutiki-botuku* (Tel.). A medium-sized to fairly large tree about 9–18 m. in height and

1–2 m. in girth with a clear bole of 4·5–9 m. Bark grey, with short narrow fissures, about 25 mm. in thickness.

It is found chiefly in the deciduous forests of North Kanara, the Deccan, Bhutan and Burma.

Description of the wood—See below.

2. E. hookeriana W. and A.—*bhonder, kunjai, kuthi* (Gond.), *bhoti* (Hind.), *dandiyase, dhasiro* (Kan.), *bundun, hakihomo, oit-bulung* (Kol.), *guakasi* (Mal-pahari), *arang, bhondia dhaman, bother, botku, bute* (Mar.), *ponra* (Oran), *bonohandi, bonokendu, bonta* (Or.), *guagoli* (Sant.), *pulichai-vandi, thuthi, uduppai, peruduppai* (Tam.), *narbotku* (Tel.). A small tree of the deciduous forests of western and southern India and Madhya Pradesh extending northwards to Chota Nagpur and Bihar.

Description of the wood—See below.

3. E. spectabilis Planchon—A small tree of the hill forests of Nepal, Manipur and upper Burma from 1050–1350 m. elevation.

Description of the wood—See below.

4. E. stocksii Hook. f.—*dhaula, giala, giali* (Aravalli hills), *jehali* (Panchmahal). A small tree closely allied to and perhaps not specifically distinct from *E. hookeriana*. *Bark* grey, with fine horizontal fissures, about 6 mm. thick

It is found in the Aravalli hills, Panchmahals, Konkan and South Deccan.

Description of the wood—See below.

5. E. wallichii DC.—A small tree. *Bark* brown about 8 mm. in thickness.

It is found in the Nepal and Sikkim Himalayas.

Description of the wood—See below.

Description of the wood

(*Eriolaena candollei, E. hookeriana, E. spectabilis, E. stocksii,* and *E. wallichii*)

(Pl. 26, 151, 152)

General properties—Sapwood light brownish-grey, darkening on exposure, about 2–3 cm. wide; heartwood sharply defined, reddish-brown to brick-red with darker streaks when first exposed, fading into a rather dull brown on exposure; hard; usually heavy (sp. gr. 0·69–0·94 air-dry); occasionally somewhat lustrous; straight-grained and medium-textured.

Gross structure—All are diffuse-porous woods. A single specimen of *E. candollei* however showed a slight ring-porous tendency. *Growth rings* usually present, but not conspicuous, delimited by a fine, more or less continuous line

of soft tissue, 2–7 per cm. *Pores* moderately large to small, fairly distinct to just visible to the eye, moderately few to moderately numerous (5–18 per mm.^{2}), mostly solitary or in radial multiples of 2–3, occasionally in tangential or oblique groups of 2–6, rounded to oval in outline, open or partially plugged with tyloses, occasionally filled with reddish-brown gummy deposits; vessel lines distinct on the longitudinal surfaces, but not conspicuous. *Soft tissues* barely visible to the eye, distinct under lens, usually forming narrow, light coloured sheaths round the pores or pore-groups, sometimes as eyelet or halo occasionally joining two or more adjacent pores by short wavy tangential bands; also as a fine more or less continuous line delimiting the growth rings. *Rays* moderately broad to fine distinct to just visible to the eye, rather prominent under lens, being of a much lighter colour than the background, uniformly distributed, somewhat closely spaced forming an inconspicuous, rather low (less than 1 mm.) fleck on the radial surface, with a distinct tendency to storied arrangement in some specimens of *E. candollei*. *Ripple marks* present, distinct in some specimens to rather faint and indistinct in others, sometimes just a suggestion, about 30–33 per cm.

Strength—*E. candollei* is reputedly a strong timber, but has not been tested at Dehra Dun. However, according to tests carried out by Brandis in 1864, the value of P (coefficient of transverse strength) is 1020, that is slightly more than sal and about 25 per cent higher than teak.

Seasoning—Not an easy timber to season as it is liable to develop longitudinal splits and surface checks. Quick conversion and careful stacking between stickers, under cover and protection from too rapid drying are recommended for satisfactory results.

Natural durability—The timber (*E. candollei*) is durable, with an average life of over 10 years in exposed situations.

Insect attack—Of all the specimens in the authentic wood collection only a single specimen of *E. stocksii* showed damage due to borer attack.

Working qualities—Rather hard to saw, but works and finishes well, both by hand as well as on machines, taking an excellent polish.

Supply and uses—Of the 5 species only *E. candollei* is of some commercial importance. However only limited supplies are available from Burma, while Bombay and Mysore can perhaps supply a small quantity of small to medium-sized logs. The timber being tough and durable is locally used for house-building, for felloes and spokes of carts, for ploughs, agricultural implements, paddles and rice-pounders. It is also said to be used for gun-stocks (Gamble), but has been tried and found unsuitable for military rifle-stocks. Howard considers it to be a valuable decorative hardwood, suitable for the European market particularly for cabinet making, inlay, turnery, etc.

Material—

E. candollei – 286 Burma (0·69), 326 Burma (0·88), 2512 Burma (0·86), 6325 Burma (0·80), 6626 Burma (0·87), 7109 Burma (0·87).

E. hookeriana – 3191 Chanda, C.P. (0·75), 3437 Palamow (0·87).

E. spectabilis – 4505 Burma (0·79).

E. stocksii – 3867 Cuddapah (0·94).

E. wallichii – 2326 Darjeeling (0·78).

2. HELICTERES L.

A tropical genus of about 45 species of shrubs or rarely trees, having a wide distribution throughout the tropics, except in Africa. The genus is represented in India and Burma by seven species, of which only one is described here.

H. isora L.—*atmora* (Beng.), *thunge-che, tingkyut* (Burm.), *aita* (Gond.), *bhendu, jonkaphal, kapasi, maraphal, marorphal, murad* (Hind.), *kauri, kavargi, kempukowri* (Kan.), *pita baranda* (Khond), *potoporla, renta, sakomsing, sinkari* (Kol.), *kayyuna, kolnaru, valambiri* (Mal.), *kevani, muradsing* (Mar.), *liniya* (Sinh.), *edampuri, karuva, kasavu, valambiri, vattachi* (Tam.), *adavichalamanthi, guba-thada, kavanchi, pedda-shamala* (Tel.). A large shrub occasionally attaining the size of a small tree. *Bark* light grey outside, fairly smooth, with fine honey-comb like fissures ; fibrous inside, about 5 mm. thick.

It is found widely distributed over the country in the sub-Himalayan tract from Jhelum eastwards to Nepal, in Bihar, East Bengal, Central and South India and also in upper Burma and Ceylon.

Description of the wood

(Pl. **26**, 153)

General properties—Wood pale yellowish-white to buff ; moderately hard, moderately heavy (sp. gr. 0·56–0·69 air-dry), usually straight-grained and rather fine-textured.

Gross structure—A diffuse-porous wood, with occasionally a slight ring-porous tendency. *Growth rings* distinct, usually demarcated by a somewhat faint and discontinuous belt of light coloured tissue, denser latewood and an occasional tendency for concentric grouping of earlywood pores, about 3–6 per cm. *Pores* small to very small, not visible to the eye but discernible with a lens, very numerous (40–50 per mm.^{2}), evenly distributed mostly in radial multiples of 2–6, but with tendency to tangential grouping at the beginning of the growth ring, rounded to oval in outline, usually open ; vessel lines not visible or inconspicuous on longitudinal surfaces. *Soft tissues* or *parenchyma*

not visible to the eye, barely visible or indistinct even under lens, in fine closely spaced, short or interrupted tangential lines, forming a fine reticulum or net-like structure. *Rays* moderately fine to fine just visible to the eye, distinct under the lens, evenly and closely spaced, without any storied arrangement.

No information is available regarding the strength and other properties of the wood. The two specimens from the authentic collection which were examined, were found to be rather badly attacked by borers. The wood is said to be used for fuel, fenceposts and roofing in thatched huts. It cuts and works rather well with a pocket knife and may do well for watch pegs, tooth-picks and applicators, where size is not of much importance.

Material—

2804 Berar (0·56), 4801 Saharanpur, U.P. (0·69).

3. HERITIERA Ait.

A small genus of 6–7 species of trees confined to tropical Asia, Africa and Australia. Atleast 5 species are known to occur in India, of which, viz., *H. fomes* Buch. and *H. littoralis* Dryand are littoral and the rest inland. Only four species for which wood specimens were available for study are described here. The woods of the species considered, closely resemble one another in practically every respect and cannot therefore be separated.

1. **H. acuminata** Wall.—*bondonthuphang* (Kach.), *thing-phelem* (Kuki), *arkhar* (Kuki and Lush.), *chokla* (Mal.), *chingren* (Naga), *rashwet* (Synteng), *chokla, sadanangu, soundalai-unnu* (Tam.), *thing-saipho* (Tippera). A middle-sized to large tree of the Khasi and Jaintia, Cachar and Lushai hills, ascending up to 600 m. ; also found in the evergreen forests of the Western Ghats in Travancore and Tinnevelly extending northwards to the Nilgiris, from 600–1200 m. elevation. The tree growing in the south is often considered as a distinct species – *H. papilio* Bedd. – closely allied to *H. acuminata* Wall.

Description of the wood—See page 201.

2. **H. fomes** Buch. (**H. minor** Lam.)—**sundri.** *sunder, sundri* (Beng.), *pinle kanazo, razo, ye-kanazo* (Burm.). A medium-sized to large tree, often buttressed, attaining a height of 15–24 m. and a girth of 1–2 m. in favourable localities. It is found gregariously in the Sundarbans and along Chittagong coast, but reaches its best development in Burma where it occurs throughout the tidal forests, from Arakan to Tenasserim.

Description of the wood—See page 201.

3. **H. littoralis** Dryander—**sundri.** In Malaya it is known as dungun. *mawtda* (Andamans), *sundri* (Beng.), *pinlekanazo* (Burm.), *chandmara* (Kan.), *sundrichand, kolland* (Mar.), *etuna* (Sinh.), *chomuntiri, kannady*

ilai (Tam.). A small to medium-sized tree about 6–12 m. in height and 1–2 m in girth. *Bark* grey or discoloured, with longitudinal fissures.

It is not found in the Sundarbans, but is otherwise more widely distributed than *H. fomes*. It grows gregariously in the tidal forests, all along the sea-shore from Chittagong to Tenasserim and is common in the Andamans. It also occurs on the west coast from Kanara southwards extending up to Ceylon, but is not common. Outside the Indian region it is widely distributed along the sea coast in tropical Asia, Africa and Australia, particularly in the Malayan region, the Philippines and Java.

Description of the wood—See below.

4. **H. macrophylla** Wall—*tepop-pomik* (Abor), *thing-ansil* (Kuki). A large evergreen tree often buttressed at the base when old. *Bark* dark brown or almost black, rather smooth, exfoliating in small square flakes, light red or whitish inside, fibrous.

It is found in the Khasi hills, Cachar, Manipur and North-East Frontier district in Assam and also occurs in upper Tenasserim in Burma.

Description of the wood—See below.

Description of the wood

(*Heritiera acuminata, H. fomes, H. littoralis* and *H. macrophylla*).

(Pl. **26**, 154, 155)

General properties—Sapwood pale pinkish brown or buff, 5–9 cm. wide, not always sharply defined, sometimes gradually merging into the heartwood; heartwood deep reddish-brown, with dark brown or purplish streaks, often darkening with age; very hard; heavy to very heavy (sp. gr. 0·84–1·20 air-dry); dull, fairly straight to somewhat interlocked-grained; even and medium to fine-textured with a rather smooth feel.

Gross structure—All are diffuse-porous woods. *Growth rings* distinct to indistinct, when distinct delimited by denser fibrous bands and sometimes by a more or less continuous line of lighter-coloured soft tissue, 3–6 per cm. *Pores* moderately large to small, mostly medium-sized, visible to the eye, few to moderately few (4–9 per mm.^{2}), fairly evenly distributed, mostly solitary or in short radial multiples of 2–3, rarely more; vessel lines distinct on longitudinal surfaces, often filled with reddish gum, but not conspicuous. *Soft tissues* not visible to the eye, distinct under lens as fine, light-coloured, closely-spaced, somewhat interrupted or dotted lines forming a reticulum or net-like structure with rays; also diffuse and scattered and sometimes as a more or less continuous fine line delimiting growth rings. *Rays* fine, barely visible or indistinct to the eye, distinct under lens, uniformly distributed somewhat closely spaced forming a low, rather inconspicuous fleck on the radial surface, the largest not more than 1 mm. in height, with a tendency for the smaller rays to be storied on the tangential

surface. *Ripple marks* usually present, rather faint and indistinct, often just a suggestion, but invariably somewhat better defined in the sapwood, about 32–40 per cm. *Gum ducts* of traumatic type occasionally present arranged in short or fairly long tangential rows embedded in a belt of soft tissue.

Strength—Of the 4 species included here, only *H. fomes* has been subjected to full scale standard tests at Dehra Dun. For strength figures please see appendix I. Some figures are also available for *H. littoralis* based on tests carried out on Ceylonese and Malayan samples. For the former, Gamble quotes, Prof. Unwin's figures obtained at the Imperial Forestry Institute, London – weight 75·47 lb. per cu. ft., resistance to shearing along the fibres 1333 lb. per sq. inch, crushing stress 2·938 tons per sq. inch, coefficient of transverse strength 6·460 tons per sq. inch, and coefficient of elasticity 737·2 tons per sq. inch. For the Malayan timber (dungun), Desch gives the following figures based on tests carried out at the Timber Research Laboratory, Sentul.

Strength figures from tests on small clear samples of H. littoralis Dryand

Series	Moisture content per cent of dry wt. at test	Wt. in lb. per cu. ft. at 15% moisture content	No. of tests	Impact bending ht. of drop of 50 lb. hammer in inches			Compression parallel to grain Max. crushing stress in lb. per sq. in.	Hardness: load in lb. to imbed a 0·444 in. diam. steel sphere to a depth of 0·222 in.		
				Max.	Min.	Av.		Radial surface	Tangential surface	End surface
1st lot	17	50	4	58	50	54	7020	2130	2160	1990
2nd lot	17	52	9	58	46	51	6980	1900	1940	1880

These figures compare favourably with those of sundri (*H. fomes*) and it appears reasonable to conclude that from the point of view of strength properties, *H. littoralis* is not much inferior to *H. fomes*, especially as all specimens of *H. littoralis* in the Dehra Dun collection were considerably heavier than the Malayan test samples, with an average sp. gr. of 0·96. The wood specimens examined of the other two species – viz., *H. acuminata* and *H. macrophylla* were practically the same as sundri in weight, hardness and structure, and may be expected to behave more or less similarly under stress.

Seasoning—The timber (*H. fomes*) is rather slow in drying and prone to fine surface cracks. Apart from this, it seasons well and develops few defects. It should be converted green and dried slowly under cover, but with good air circulation. Kiln-seasoning at rather low temperatures has been found to give satisfactory results during trials conducted at Dehra Dun. *H. littoralis* is also subject to surface cracks and is liable to end splitting. Good results can however, be obtained by careful air-seasoning or kiln-seasoning.

Natural durability—Though both sundri (*H. fomes*) and dungun (*H. littoralis*) are reputed to be very durable timbers, there are no experimental

data to substantiate this. In actual graveyard tests carried out at Dehra Dun sundri was found to have an average life of only 3–4 years. According to Desch *H. littoralis* also behaved more or less similarly in tests carried out in Malaya, only 3 out of 11 pieces surviving a little over 5 years. *H. acuminata* and *H. macrophylla* are also probably of the same durability class. The latter is susceptible to attack by wood rotting fungi.

Insect attack—In both *H. fomes* and *H. littoralis* sapwood of logs, especially when newly felled, is liable to be attacked by shot-hole borers. Of the 16 specimens in the Dehra Dun wood collection, only one specimen of *H. littoralis* showed insect attack in the sapwood. Desch reports that one specimen of the same species in the Kepong collection is attacked by a long-horn borer. The timber is said to possess some resistance to marine borer attack (Bianchi).

Preservative treatment—According to Trotter the sapwood treats readily with preservatives, but the heartwood is more refractory, penetration being patchy.

Working qualities—Both sundri and dungun being very hard are rather difficult to saw, but otherwise machine well and can be worked to an excellent surface taking a high finish and a beautiful polish.

Supply and uses—Supplies of sundri (*H. fomes*) in India are either practically exhausted or are so negligible as to be of little commercial importance. The timber however is available in commercial quantities from East Pakistan and Burma. Considerable supplies of *H. littoralis* should also be available from the Andamans. Sundri is known to be extensively used for boat-building as planking, oars, spars and masts. It is also commonly employed in carriage building for shafts, felloes and spokes and in construction work for beams, posts and piles for bridges. The timber has been used and found satisfactory for picker arms and tool handles particularly of the larger and heavier type. On account of its hardness, toughness and strength it is suitable for agricultural implements, pulley-blocks, tent-pegs and pit-props. It has been tried by some paper mills in India for suction box covers with satisfactory results. It also yields an excellent firewood and is very much in demand for fuel purposes. The timber of *H. littoralis* though not so well known is used for similar purposes in Burma. The wood of *H. acuminata* is locally used in the south for construction work, carriage building and agricultural implements and should be capable of being put to the same uses as sundri.

Material—

H. acuminata – 5163 Travancore (1·04).

H. fomes – 3123 Burma (1·10), 5361 Burma (0·95), 5742 Burma (1·06), 6451 Burma (0·95), 5742 Burma (1·06), 6451 Sundarbans (0·88), 6531 Burma (1·06), 7299 Sundarbans (1·06), 7302 Sundarbans (0·93), 7305 Sundarbans (0·95).

H. littoralis – 517 Andamans (0·92), 2226 Andamans (0·85), 2285 Andamans (1·02), 2916 Andamans (1·10), 5832 Andamans (0·90).

H. macrophylla – 6417 Burma (0·94).

4. MANSONIA J. R. DRUMM.

A small genus of trees, with somewhat limited distribution. Of the 5 species recorded, three have been reported from tropical Africa while the other two are confined to India and Burma. The woods of the two species described here are very dissimilar, and can be distinguished from each other without much difficulty.

Key to the species

Pores minute, indistinct under lens, very numerous; ripple marks present but not very prominent, 32–36 per cm. Wood very hard, extremely fine-textured, occasionally scented ... *M. gagei*

Pores medium-sized to small, just visible to the eye, distinct under lens, moderately numerous to numerous; ripple marks very prominent, 20–24 per cm. Wood moderately hard, medium-textured, not scented ... ... *M. dipikae*

1. **M. dipikae** Purkay.—*badam, lapse, lapseodal* (Asm.). A large tree about 25–35 metres in height and 3 metres in girth. *Bark* greyish-white with longitudinal fissures.

It is found in the Dhansiri Reserve, Nowgong and Rangpahar Reserve of Naga Hills in Assam.

Description of the wood

(Pl. 26, 156)

General properties—Sapwood pale yellowish or greyish-white about 4–6 cm. wide; heartwood sharply defined, yellowish to greyish-brown, often with darker purplish-brown streaks; moderately hard; moderately heavy (sp. gr. 0·60–0·66 air-dry); somewhat lustrous but without any distinct scent; straight-grained; even and somewhat coarse to medium-fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* fairly distinct to indistinct; when distinct delimited by denser latewood and sometimes by a more or less continuous line of soft tissue, 3–7 per cm. *Pores* medium-sized to small, just visible to the eye, distinct under lens, moderately numerous to numerous (14–37 per mm.^{2}) more or less evenly distributed, solitary or in radial multiples of 2–3 occasionally 4, rounded to oval in outline, usually open; vessel lines

visible on the longitudinal surfaces, but rather inconspicuous. *Soft tissues* or *parenchyma* indistinct or just visible under the lens, scattered or diffuse and in fine short, broken tangential lines forming an irregular net-like structure. *Rays* fine, not visible to the eye, distinct under lens, evenly and closely spaced forming an inconspicuous fleck less than 0·5 mm. high on the radial surface, distinctly storied. *Ripple marks* present, well defined, very prominent to the eye as well as under lens, about 20–24 per cm.

Strength—From the limited tests carried out at Dehra Dun it appears to be a rather strong timber for its weight comparing favourably with walnut. For strength figures please see appendix I.

Seasoning—Not tested at Dehra Dun. However, *Mansonia altissima* A. Chev. from West Africa (sp. gr. 0·61 air-dry), which is very similar to *M. dipikae* in practically every respect and cannot be distinguished from it, is known to air season readily with little degrade apart from splitting of the knots. The African species also kiln seasons fairly rapidly and well, the amount of shrinkage being very low 2·7–3·1 per cent tangentially and 0·9–1·5 per cent radially while drying from the green condition to about 10 per cent moisture content. The Indian species may be expected to behave somewhat similarly.

Natural durability—The timber is still under test at Dehra Dun. Inspection after one year showed all heartwood specimens to be perfectly sound. *Mansonia altissima* is said to be very resistant to decay.

Insect attack—None of the specimens in the Dehra Dun collection showed any insect attack. Logs of *M. altissima* are however, reported to be susceptible to pin-hole borer and long-horn beetle damage, which is usually confined to the sapwood.

Preservative treatment—From the limited tests so far carried out at Dehra Dun, the heartwood appears to be refractory to treatment even under pressure.

Working qualities—Easy to work and planes to a good, smooth finish. *Mansonia altissima* is reported to nail, screw and glue satisfactorily taking an excellent polish. Though not very suitable for peeling on a rotary machine, the African timber is said to yield very good veneers when sliced. The saw-dust from the dry timber however is sometimes reported to cause skin and nasal irritation and smarting of the eyes.

Supply and uses—The timber is available only in Assam, and supplies are naturally limited. It is a handsome timber, very much resembling walnut in appearance, strength properties and working qualities and should prove suitable for most purposes for which walnut is used, particularly high class furniture, cabinet work, show-cases and, panelling. It may be worthwhile trying for carving and turnery work and even for rifle-stocks. The light coloured

sapwood, which is often very wide should be useful for drawing and mathematical instruments.

Material—

8005 Assam (0·60), 8006 Assam (0·63), 8007 Assam (0·63), 8009 Assam (0·65), 8010 Assam (0·66).

2. **M. gagei** Drumm.—**kalamet.** A small to medium-sized tree about 12 m. in height and about 1 m. in girth, confined to South Tenasserim in Burma.

Description of the wood

(Pl. 27, 157)

General properties—Sapwood pale yellowish or brownish-white darkening on exposure, rather wide; heartwood sharply defined, deep reddish or olive brown, with darker purplish-brown or chocolate coloured streaks; very hard; heavy to very heavy (sp. gr. 0·82–0·97 air-dry), rather dull with a somewhat oily, but smooth feel; sometimes with a sweet scent resembling that of eaglewood, fairly straight to interlocked-grained; even and very fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* usually indistinct, sometimes faintly delimited by denser latewood and a somewhat broken line of soft tissue, 4–8 per cm. *Pores* very small to extremely small, not at all visible to the eye, not distinct or barely visible under the lens, very numerous, more or less evenly distributed, solitary or in radial multiples of 2 to 3, occasionally 4 or more, rounded to oval in outline, open or plugged with reddish-brown deposits; vessel lines not visible on the longitudinal surfaces. *Soft tissues* or *parenchyma* indistinct or not visible even under lens. *Rays* very fine, not visible to the eye, distinct under lens, evenly and closely spaced, forming a very inconspicuous fleck on the radial surfaces, distinctly storied. *Ripple marks* present, distinct, but much finer and less conspicuous than in *M. dipikae*, about 32–36 per cm.

No information is available regarding the mechanical and other properties of this wood, as it has not been tested at Dehra Dun or elsewhere. Of the three specimens examined, two show borer damage. Being fine-textured and scented it has been reported to be used as a substitute for sandalwood.

Though hard, it appears to be suitable for small carved wooden pieces. It is also said to be used as a cosmetic by Burmese ladies.

Material—

1950 Burma (0·97), 6788 Burma (0·82), 6827 Burma (0·83).

5. PTEROSPERMUM SCHREB

A tropical Asiatic genus of about 20 species of trees distributed throughout South and South-East Asia, the Andamans, Java, Borneo and the Philippines.

About a dozen species occur in the Indian region, of which 9 are described here. Except for slight variations in weight and hardness, the woods of the species included here are very similar and cannot be distinguished from one another.

1. **P. acerifolium** Willd.—**hathipaila.** *sipon-asing, tepop-paplok* (Abor), *bon-morla, hatipeala, larubanda, moragos, morra, mota-marulia* (Asm.), *kanak-champa, kuchokunda, mus* (Beng.), *magwi-napa, sinna, taung-petwun* (Burm.), *taguru changne* (Duff.) *mat-bul-japha, rikhabok* (Garo), *mayeng* (Jaunsar), *laidorbuphang, lau-gongrai-baphang, rangirata* (Kach.), *dieng-dit-la-khoh, dieng-khoh, dieng-khong-swet, dieng-myrhaw, dieng-sla-um-pai, dieng-tharo-masi* (Kh.), *nakhar-theng* (Kuki), *numblong* (Lep.), *waisil-thing* (Lush.), *gaik* (Magh), *kukla* (Manipur), *makchand* (Malpahari), *kanak-champ, karnikar* (Mar.), *kongla-arong, lokong-krong-arong, lopok-lok-arong* (Mik.), *hatipaile* (Nep.), *machkund* (Sant.), *modubura* (Sylhet), *thadaya-maram* (Tam.), *avor, ching-pha* (Tippera). A large tree up to 24 m. in height and 1·5–2·5 m. in girth with a clear cylindrical bole of 9–12 m. *Bark* grey or brown outside, smooth to somewhat rough, inside purplish with white streaks, thin.

It is found in the sub-Himalayan tract from Jumna eastwards in Uttar Pradesh, North Bengal, hills of Assam, Chittagong and Burma. It also occurs scattered in Bihar, Madhya Pradesh and Orissa and is often planted as an ornamental tree.

Description of the wood—See page 208.

2. **P. glabrescens** W. and A.—*pambaram* (Mal.), *mooli, vatta-polavu* (Tam.). A medium-sized tree up to 18 m. in height and 1–1·5 m. in girth.

It is found in the Western Ghats from South Kanara to Travancore at elevations of 300–600 m., not common.

Description of the wood—See page 208.

3. **P. heyneanum** Wall.—*kesali, oopin* (Kan.), *mala-vuram, nay unam, palaka-unam, thopali* (Mal.), *giringa* (Or.) *udupai, polavu* (Tam.), *tada thada* (Tel.). A middle-sized tree of the forests of Deccan, on the east coast and inland hills in Ganjam, Northern Circars and Cuddapah.

Description of the wood—See page 208.

4. **P. jackianum** Wall.—*ngwe-la-byin, taung-myingye* (Burm.). A medium-sized to large tree of Tenasserim. Also found in Cochin-China and extending southwards to Penang.

Description of the wood—See page 208.

5. **P. lancaefolium** Roxb.—*bon-baguri, bon-nahor, bon-tituli, mota-nahor* (Asm.), *ban-kali* (Beng.), *pung-i-tabri* (Duff.), *bol-nabat, bokta* (Garo), *lai-kulaiphang* (Kach.), *dieng-nor-sha* (Kh.), *phong-arong, theng-pitula-arong* (Mik.), *nahorobu* (Miri), *chingnai* (Naga), *singani* (Nep.), *narch* (Sylhet),

phai-bomarta (Tippera). A medium-sized to large tree of Khasi hills, Manipur and Chittagong.

Description of the wood—See below.

6. **P. reticulatum** W. and A.—*mala-vuram* (Mal.), *muli polavu, tholpuli* (Tam.). A medium-sized tree of the forests of Malabar and Travancore, occurring at low elevations.

Description of the wood—See below.

7. **P. rubiginosum** Heyne—*malam-thodali, mala-vuram* (Mal.), *chinna polavu, chittalai polavu* (Tam.) A tall tree up to 24 m. in height and about 2 m. in girth, found chiefly in the evergreen forests of the Western Ghats from Malabar southwards, ascending up to 900 m. elevation.

Description of the wood—See below.

8. **P. semisagittatum** Ham.—*nagye, najyay-pen, nakyay-pen* (Burm.), *nwaleinbyeng* (Magh). A medium-sized tree, 15–18 m. in height and 1–2 m. in girth with clear bole of 8–9 m. usually fluted. *Bark* grey, thick.

It occurs in Chittagong and all over Burma.

Description of the wood—See below.

9. **P. suberifolium** Lam.—*baili* (Khond), *muchucuda* (Mar.), *baclo, bayalo, giringa, makai-champa* (Or.), *welanga* (Sinh.), *polavu, muravanka senolugu, vinaku* (Tam.), *lolugu, thada* (Tel.). A small to medium-sized tree of the forests of Deccan on the east coast and inland hills in Orissa, Northern Circars extending southwards to Cuddapah. It is also found in the drier regions of Ceylon but its occurrence in Kanara and Konkan is rather doubtful.

Description of the wood

(*Pterospermum acerifolium, P. glabrescens, P. heyneanum, P. jackianum, P. lancaefolium, P. reticulatum, P. rubiginosum, P. semisagittatum, P. suberifolium*).

(Pl. 27, 158)

General properties—Sapwood distinct from heartwood in *P. acerifolium*, white; heartwood in all the Indian species described here, light greyish or pinkish-brown to light reddish-brown often with a distinct purplish tinge, turning somewhat darker on exposure; soft to moderately hard, and usually moderately heavy, occasionally somewhat lighter or heavier (sp. gr. 0·44–0·77 air-dry); rather lustrous; fairly straight to slightly interlocked-grained and medium-fine-textured.

Gross structure—All are diffuse-porous woods. *Growth rings* indistinct to distinct, often irregular in contour, demarcated by the slightly denser and darker coloured latewood fibres, 2–6 per cm. *Pores* visible to the eye, distinct under the lens, medium-sized to small, moderately few to moderately numerous

(5–20 per mm.^{2}), sometimes fewer, rarely more numerous, more or less evenly distributed, solitary and in short radial multiples of 2–3, occasionally more or in small clusters, in contact with rays on both sides, mostly oval in outline and open ; vessel lines visible but not prominent. *Soft tissues* or *parenchyma* not visible to the eye but seen under the lens, usually occurring as fine, closely-spaced, interrupted or broken tangential lines extending from ray to ray, occasionally tending to be diffuse and not very distinct. *Rays* usually fine, occasionally somewhat broader, all more or less of the same size, indistinct to the eye being of the same colour as the background, visible under lens, usually numerous and closely spaced, but sometimes fewer and a little further apart, rather low and not very distinct on the radial surface, mostly storied. *Ripple marks* present, due to storied rays and parenchyma, usually distinct, visible both to the eye as well as under the lens, sometimes rather faint and irregular and difficult to count, about 30–40 per cm.

Strength—Of the species included here, only *P. acerifolium* has been tested for strength at the Institute, and the other remarks that follow also are based mostly on observations made on this timber. For strength figures please see appendix I.

Seasoning—Apart from a tendency to develop surface cracks the timber is easy to season. Green conversion and open stacking under cover, away from direct sun are recommended for satisfactory results.

Natural durability—Not durable in the open, but fairly so under cover. According to Burkill, in Java, the timber of *P. diversifolium* Bl. is said to be excellent in contact with water, which however, is contrary to Reyes observations on Philippine timber of the species.

Preservative treatment—Heartwood is only partially treatable.

Working qualities—The timber presents no difficulty when sawn green. It is easy to work both by hand and with machines and finishes well taking a good polish.

Supply and uses—Moderate supplies of *Pterospermum acerifolium* are available from the east zone, chiefly Assam and also from Burma. The supplies from the north zone including Uttar Pradesh and Himachal Pradesh are limited. The other species are not exploited on a commercial scale being used only locally. The timber of *P. acerifolium* is used chiefly for planks, packing cases and turnery articles. It has been tried for matches and match-boxes and not found suitable. Though not tested for plywood at Dehra Dun it has been tried for this purpose in Assam and gives a good commercial plywood for general use. *P. rubiginosum* is locally used on the west coast for house-building and boats. According to Reyes, the Philippine timbers of the genus chiefly *P. diversifolium* are used for house-building, furniture, cabinet work, turnery and household and agricultural

implements. The Malayan species *P. javanicum* is said to be used for bridges, house-construction and boats (Heyne).

Material—

P. acerifolium – 593 Darjeeling terai (0·76), 2510 Burma (0·73), 3135 Darjeeling terai (0·73), 5315 Dehra Dun, U.P. (0·72), 5814 Dehra Dun, U.P. (0·64), 6294 Burma (0·57), 6685 Rangoon (0·52), 6873 Motichoor, U.P. (0·68).

P. glabrescens – 4532 Travancore (0·44).

P. geyneanum – 4225 Cuddapah (0·72), 4581 Travancore (0·68), 6265 Madras (0·74).

P. jackianum – 7151 Burma (0·70).

P. lanceaefolium – 4645 Dehra Dun, U.P. (0·68).

P. reticulatum – 6196 Kanara (0·68).

P. rubiginosum – 4531 Travancore (0·71).

P. semisagittatum – 2511 Burma (0·62), 2706 Tavoy (0·77).

P. suberifolium – 1250 Ganjam (0·56), 1311 Ganjam (0·55), 3534 Orissa (0·69).

6. STERCULIA L.

(Including *Firmiana* Marsigli, *Pterocymbium* R. Br., *Pterygota* Endl. and *Scaphium* Endl.)

A large genus of usually soft and light wooded trees reaching its best development in tropical Asia. It consists of well over hundred species of which about twenty are represented in the Indian region. Woods of only thirteen of these were available for study and are included here. The woods, though usually soft and light and somewhat similar in their general properties, show considerable variation in their anatomical structure and are therefore considered here separately under five distinct groups. Based on gross anatomy it has been found possible to correctly assign woods of the genus, to respective groups of species, and in some cases even to particular species. It is interesting to note in this connection that some systematic botanists have also split up the genus into a number of genera, which are to some extent in general agreement with the grouping based on gross structure.

Key to the species

1. Heartwood usually distinct from sapwood, reddish-brown ... 2
1. Heartwood usually not distinct from sapwood, creamy or greyish-white to light greyish-brown 3

2. Broad tangential bands of soft tissue present at irregular intervals. Gum ducts usually present in long tangential rows ... ... *S. urens*

2. Broad tangential bands of soft tissue not present. Gum ducts absent ... ... *S. foetida*

3. Soft tissues in broad, wavy or fairly straight tangential bands... ... ... *S. alata*
S. coccinea
S. colorata
S fulgens
S. populifolia

3. Soft tissues not in broad, wavy or fairly straight tangential bands 4

4. Soft tissues present, in numerous fine interrupted tangential lines, distinct, often appearing as fine, closely spaced dots under lens; and also round the pores, but not well defined ... *S. angustifolia*
S. guttata
S. ornata
S. villosa

4. Soft tissues in numerous fine interrupted or broken tangential lines absent, or if present, not visible under lens. Soft tissues round the pores distinct and well defined 5

5. Growth rings indistinct, not delimited by a layer of soft tissue. Soft tissue round the pores, in a thin sheath forming a distinct halo ... ... *S. campanulata*

5. Growth rings distinct, delimited by a continuous layer of soft tissue. Soft tissue round the pores, often aliform, forming an eyelet not infrequently connecting adjacent pores ... ... *S. scaphigera*

1. **S. alata** Roxb. [**Pterygota alata** (Roxb.) R. Br.]—**narikel.** *pahari* (Asm.), *tula* (Beng.), *haron, let-kok, sinkadet* (Burm.), *budda-narikel* (Chittagong), *mibol* (Garo), *bandar-pela, thailokhrong* (Kach.), *talbe-mara, tattele* (Kan.), *dieng-klong, dieng-soh-lakor* (Kh.), *bantai* (Kuki), *phunder-pui* (Lush.), *hangkyow* (Magh), *anathondi, kodathani, poola, porla, pothondi* (Mal.), *bara-laiphanzeh* (Mechi), *bong-long-thing, pong-long-thing* (Mik.), *khamari, labshi, muslini* (Nep.). A large tree attaining in favourable localities a height of over 45 m. and a girth 2·5–3 m. with a straight cylindrical bole of 24–30 m. up to

the first branch, often buttressed at the base. *Bark* greyish-brown outside, fairly smooth, but corky with horizontal wrinkles and shallow vertical fissures, showing green underneath, and fibrous inside, rather thick.

It is found in the evergreen forests of North-East India, particularly Assam and in the Western Ghats from North Kanara to Travancore ascending up to 900 m. but reaches its best development in Chittagong, Burma and the Andamans.

Description of the wood—See page 217.

2. **S. angustifolia** Roxb.—*mainma-shaw* (Burm.). A small to medium-sized tree found in lower Burma from Martaban to Tenasserim. This species is considered by some botanists as not distinct from *S. balanghas* L. – *narthondi*, *nattuthondi* (Mal.), *nava* (Sinh.), *kavalam* (Tam.). A medium-sized tree of the Western Ghats from Malabar southwards and the low country of Ceylon.

Description of the wood—See page 219.

3. **S. campanulata** Wall. ex Mast. [**Pterocymbium tinctorium** (Blanco) Merr.]—**papita.** *papita* (Andamans), *sawbya*, *shaw-pya* (Burma). A large tree 30–40 m. in height and 2·5–3 m. in girth with a 24–30 m. straight, cylindrical bole without any buttresses. *Bark* grey and patchy.

It is found in lower Burma from Martaban to Mergui and Tenasserim and in the Andamans, where it is also grown in plantations. It also occurs in the Malay Peninsula and Java.

Description of the wood

(Pl. 27, 160)

General properties—Sapwood and heartwood not distinct. Wood creamy-white to oat-meal coloured, often showing dirty grey discoloration ; soft to very soft, often easily dented with a finger nail, very light (sp. gr. 0·21–0·34 air-dry), lustrous on radial surface when not discoloured ; straight-grained, even and coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct to fairly distinct demarcated by the slightly thicker-walled latewood fibres and sudden flaring or widening of the rays. *Pores* large to moderately large, distinctly visible to the eye, few (2–4 per mm.^{2}), more or less evenly distributed, mostly solitary, but sometimes in short radial multiples of 2–3, rounded to oval in outline, open ; vessel lines straight, distinct to rather conspicuous. *Soft tissues* or *parenchyma* indistinct to the eye, but visible under the lens forming a more or less well-defined sheath or halo round the pores ; also diffuse and in numerous fine interrupted tangential lines, indistinct or not visible even under lens, due to the extremely thin-walled fibres, which can often be seen

individually with a lens. *Rays* of two sizes, very broad to moderately broad and fine, the former prominent to the eye, the largest being of the same width or occasionally even wider than an average sized pore, widely spaced, forming a conspicuous lustrous fleck on the radial surface about 2·5 mm. or more in height and the latter very few and visible only under the lens; not storied. *Ripple marks* indistinct or not visible to the eye, rather faint and irregular even under lens, sometimes just a tendency due mostly to the storied arrangement of the fibres, parenchyma and vessel elements. *Gum ducts*, occasionally present, traumatic and arranged in long tangential bands.

Strength—Only a small consignment has been tested at the Forest Research Institute, Dehra Dun. For strength figures please see appendix I.

Seasoning—Easy to season without much degrade. However, the logs should be converted absolutely green immediately after felling and open-stacked under cover so as to prevent sap stain and discoloration, which are common. Kiln seasoning gives the best results.

Natural durability—Very perishable in exposed situations and in contact with the ground, but if properly seasoned lasts fairly well under cover.

Insect and fungus attack—Both logs and converted timber are subject to damage by insects, chiefly powder-post beetles and shot-hole and pin-hole borers. Logs and unseasoned timber are also easily susceptible to blue sap stain and fungus attack.

Preservative treatment—No data are available.

Working qualities—The timber is very easy to saw and work both by hand as well as with machines. When quarter sawn it gives pleasing lustrous boards.

Supply and uses—The chief sources of supply are the Andamans, where abundant supplies are available. The timber is used mainly for light packing-cases and is in great demand by the match industry for match-splints as well as boxes. It has been tried at the Forest Research Institute, Dehra Dun for both chemical and mechanical pulp for writing and printing papers and found suitable. According to Reyes the timber is used in the Philippines also for rafts (floaters), fish-net floats and wooden shoes.

Material—

6083 Andamans (0·34), 6547 Burma (0·26), 6844 Burma (0·22).

4. **S. coccinea** Roxb.—*nak-chepeta* (Asm.), *kyiat, makai, shawa* (Burm.), *tatom-pelom-changne* (Duff.), *kanthior-kung, katior* (Lep.), *konkelu* (Mik.), *sagle-papio* (Miri), *chiwari-pat, sitto-udal* (Nep.). A shrub or small tree. *Bark* grey and warty outside, green underneath.

It is found in the eastern Himalayas, ascending up to 900 m. in Bhutan, Sikkim and Assam hills and in Burma extending southwards to Tenasserim.

Description of the wood—See page 217.

5. **S. colorata** Roxb. [**Firmiana colorata** (Roxb.) R. Br., **Erythropsis colorata** Ridley]—*berda* (Andamans), *jari-udal, jhari-udal, kath udal* (Asm.), *moola* (Beng.), *khowsey pini* (Burm.), *bhari-koi khansi* (Bombay), *gupchyu, gupju, gupju-hta, mai-paw-che, ta-u-shaw, wetshaw* (Burm.), *balazong, bolajun, chengsu, walgem* (Garo), *bodala, bodula, samarri, walena* (Hind.), *lerisma* (Kharwari), *dieng-sangkhlor, dieng-symphlor* (Kh.), *sisi* (Kol), *malamparathi* (Mal.), *natol* (Malpahari), *kowsey* (Mar.), *bohog-odla* (Mech.), *mutruk* (Merwara), *omra, phirphiri, seto-udal* (Nep.), *kodalo, pani-kodal* (Or.), *sisir* (Oran), *udal* (Sant.), *malai-parutti* (Tam.), *garasingi, karaka, kondat-mara, yerra-puliki* (Tel.), *kenawila* (Vedda). Usually a medium-sized tree, 9–15 m. in height, and 1–1·5 m. in girth, with a clear bole of 6–9 m., occasionally larger reaching up to 24 m. in height and over 2 m. in girth. *Bark* whitish-grey, fairly smooth.

It has a wide distribution in India being found throughout the sub-Himalayan tract from the Jumna eastwards, ascending up to 1200 m. in Assam and in Central and South India in the Deccan, Western and Eastern Ghats. It also occurs in Burma and the Andamans.

Description of the wood—See page 217.

6. **S. foetida** L.—*goldaru, kua-mhad, nagal-kuda, virhoi* (Bombay), *kadung-hta, letkok, letkop, let-pan-shaw, shawbyu, shaw-wah* (Burm.), *janglibadam* (Hind.), *kudre-goit, penari, sembadi* (Kan.), *pinari, potta-kavalam, thondi* (Mal.), *telambu* (Sinh.), *kudra-pudukku, ottai-pudukku, pee, pee-nari, pinari* (Tam.), *gorapu-badam, gurapu-vadam* (Tel.). A large tree 24–27 m. in height and 2·5–3 m. in girth, with a clear bole of 12–18 m. *Bark* whitish, flaky and thick.

It is found on the west coast at low elevations from Konkan southwards, Ceylon and Martaban and upper Tenasserim in Burma. Outside the Indian region it has a wide distribution from tropical East Africa to North Australia.

Description of the wood—See page 220.

7. **S. fulgens** Wall. [**Firmiana fulgens** Wall., **Erythropsis fulgens** Ridley]. A tree of Burma, Malay Peninsula, Java and Sumatra.

Description of the wood—See page 217.

8. **S. guttata** Roxb.—*hirik* (Asm.), *kappu-savaga, kampirike, kudregonatti* (Kan.), *kavalam, kithondi, thondi* (Mal.), *chakra, goldar, koketi, kookar, kukari* (Mar.), *kavili, thondi* (Tam.). A medium-sized to large tree up to

18 m. in height and about 2 m. in girth, often buttressed. *Bark* brownish or greyish-white, rather smooth, about 12 mm. thick.

It occurs in the evergreen forests of the Western Ghats from Konkan to Travancore, ascending up to 600 m. in Assam and also in Tenasserim in Burma.

Description of the wood—See page 219.

9. **S. ornata** Wall.—*gahta, hta, kahta, pawlin, penleng, shaw-prwah, shawni, shaw-wa* (Burm.). A medium-sized to fairly large tree very similar to *Sterculia villosa* Roxb., 15–18 m. in height and 1–1·5 m. in girth with a clear bole of 8–12 m. *Bark* light brown and smooth with scattered, oval or oblong, vertically arranged lenticels, about 5–6 mm. in thickness.

It is found chiefly in the tropical forests of lower Burma, from the Pegu Yomas downwards to Martaban and Tenasserim.

Description of the wood—See page 219.

10. **S. populifolia** Roxb.—*delibuda* (Tel.). A small tree of the hills of the Deccan and Eastern Ghats. *Bark* grey and fibrous, about 10–12 mm. thick.

Description of the wood—See page 217.

11. **S. scaphigera** Wall. [**Scaphium wallichii** Schott. and Endl.]—*shaw, taung-thinbaw, thibyu, thitlaung* (Burm.). A large tree 27–36 m. in height and 2–3 m. in girth with a clear bole of 15–20 m. often deeply fluted and heavily buttressed. *Bark* greyish-brown outside, peeling off in irregular flakes, fibrous inside, about 12 mm. thick. A tree of the tropical forests of Pegu Yomas, Martaban and Tenasserim in Burma, it is also found to some extent in Chittagong.

Description of the wood

(Pl. 28, 163)

General properties—Sapwood and heartwood not distinct. Wood pale greyish or yellowish-white to light buff ; soft and light (sp. gr. 0·45–0·52 air-dry) ; somewhat lustrous when quarter sawn ; straight-grained and rather coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct demarcated by a continuous line of soft tissue, 2–5 per cm. *Pores* visible to the eye, though outlines not very distinct, large to small, mostly moderately large or medium-sized, few (2–5 per mm.^{2}), evenly distributed usually solitary and in short radial multiples of 2–3, rounded to oval in outline, open. Vessel lines distinctly visible but not prominent. *Soft tissues* or *parenchyma* just visible to the eye, distinct under the lens, in continuous lines or layers delimiting the growth rings, and also paratracheal often forming an eyelet and sometimes connecting adjacent pores by lateral extensions. *Rays* of two distinct sizes,

moderately broad and very fine, the former distinctly visible to the eye, the largest being of about the same width as an average-sized pore widely spaced, forming a fairly conspicuous fleck on the radial surface, not storied; the latter visible only under the lens, mostly uniseriate, fairly colsely spaced, storied. *Ripple marks* fairly distinct to rather faint and irregular due to the storied arrangement of the small rays and fibres, about 20–24 per cm. *Resin canals* not observed in the specimens studied; Desch has, however, recorded traumatic resin canals in the closely allied Malayan species *Scaphium affine* Pierre.

No information is available regarding the strength, durability, seasoning properties and uses, etc., of this wood. According to Burkill, the timber from *Scaphium affine* of Malaya "can be used for planking and is sometimes sawn". But on the other hand Desch says that on account of their high silica content it is doubtful whether the Malayan woods of the genus *Scaphium* can be profitably worked. However, he reports that "experimental peeling of logs yielded veneer that made up into pleasing plywood panels". The wood of the species described here does not appear to contain appreciable quantities of silica, and should therefore be not difficult to work. From its appearance and general properties it should prove suitable for plywood, veneers, light packing cases and other uses for which *semul* is commonly in demand.

Material—

6421 Burma (0·52), 7120 Burma (0·45).

12. **S. urens** Roxb.—*kalru* (Ajmere), *hatchand*, *odla* (Asm.), *guru*, *kaira*, *kalu*, *karaj*, *taklej* (Berar), *shaw* (Burm.), *katira* (Garhwal), *hittum*, *pino* (Gon.), *kada*, *karai* (Guj.), *gular*, *gulu*, *karrai*, *kulu*, *tabsi*, *tanuku* (Hind.), *kaddu*, *karr* (Jeypore), *kempudale* (Kan.), *kud* (Khandesh), *kaunji* (Kharwari) *genduli* (Khond), *teley* (Kol), *khonji* (Koderma), *takli* (Kurku), *anainar*, *thondi*, *vakka* (Mal.), *keonge* (Manbhum), *gwira*, *kandol*, *karai*, *saldawar* (Mar.), *karaunji*, *mogul* (Monghyr), *girunjila*, *kodaro* (Or.), *keonji* (Oran), *kalauri* (Panchmahals), *ganjher*, *karaunji*, *keonji*, *telhee* (Sant.), *kavalam*, *kavali*, *senthanuku*, *vellay putali* (Tam.), *tabsu*, *yerra poliki* (Tel.). A moderate-sized to large tree which in Burma according to Kurz, sometimes reaches up to 18 m. in height and 2·5–3 m. in girth with a clear bole of 12 m. In India it is usually a much smaller branching tree up to 2 m. or more in girth, but rarely more than 4·5 m. up to the first branch. *Bark* greenish-grey or ash-coloured and smooth, peeling off in large papery flakes.

It is found in the sub-Himalayan tract from the Ganga eastwards, throughout dry rocky forests of the Deccan plateau, hills of Rajputana and central India and also in lower Burma and Ceylon ascending up to 900 m.

Description of the wood—See page 220.

13. **S. villosa** Roxb.—**Udal.** *sergok-asi* (Abor and Miri), *chilka*, *lal-chilka* (Andamans), *odal*, *odela*, *odla*, *omak*, *salua*, *udal* (Asm.), *gahta*, *hta*, *kahta*,

pawleng, shawghaw, shawnee, shawni (Burm.), *udal* (Cachar, Duff. and Sylhet), *udalia* (Doti.), *udalu* (Garhwal), *ubak udare, umak, upak,* (Garo), *baringa, kudar* (Gon.), *god-gudala, odal, odala, udal, udar* (Hind.), *dukhundu-phang, takundu-phang* (Kack.), *bilidale, chauri, kaithali, kalsoge, sage, samikai, savaya* (Kan.), *udal* (Kharwari), *dieng-star* (Kh.), *pironja, sisi, walkom* (Kol.), *ruija* (Kuki), *fudalu* (Kumaon), *buti* (Kurku), *kanhlyem* (Lep.), *sambeing* (Magh), *vakka, vekka* (Mal.), *kuthada, sarda, sarde* (Mar.), *odal* (Mechi), *chekong-arong, jinje-kong, kong-kulu, theng-chi-kong-long* (Mik.), *pironja* (Mundari), *heppuk-bang* (Naga), *odal* (Nep.), *kodalo* (Or.), *sisir* (Oran), *god-godalo, gul-bodla, gul-kandar, massu* (Punj.), *ganjher, udale* (Sant.), *poshwa* (Sutlej), *anai-nar, arni, kavali, kottai-thanuku, muruthan, vakkainar* (Tam.), *kummari-poliki* (Tel.), *chop*(Tha.), *japui-kung* (Tippera), *dadiya* (Vedda). A medium-sized to large tree of the tropical forests reaching its best development on the Andamans and Burma, where it often attains a height of 18–24 m. and a girth of 1·5–2·5 m. with a clear bole of 12–15 m. In India proper it is a much smaller tree reaching only 1–1·5 m. in girth in favourable localities as in U.P. *Bark* grey outside, fairly smooth with numerous corky warts, light red and fibrous inside about 25 mm. thick.

It ascends to over 1,000 m. and is found throughout India, Burma and the Andamans except in the arid regions.

Description of the wood—See page 219.

Description of the wood

(*Sterculia alata, S. coccinea, S. colorata, S. fulgens,* and *S. populifolia*)

(Pl. 27, 159, 161 and 162)

General properties—Sapwood and heartwood not distinct ; wood greyish or pale yellowish-white to light greyish-brown, often showing greyish-black discoloration ; usually very soft to soft and very light to light (sp. gr. 0·26–0·48 air-dry), but sometimes moderately hard and moderately heavy (sp. gr. up to 0·62 air-dry) in *S. alata* ; somewhat lustrous on the radial surface when not discoloured, particularly in *S. alata* ; usually straight-grained and coarse-textured.

Gross structure—All are diffuse-porous woods. *Growth rings* indistinct to fairly distinct, demarcated by somewhat denser and darker latewood, 1–5 per cm. *Pores* large to moderately large, occasionally medium-sized, usually few to very few (1–5 per mm.^{2}), sometimes or in portions moderately few to moderately numerous and hence somewhat unevenly distributed, solitary or in short radial multiples of 2–3, occasionally in large multiples and small rounded clusters, rounded to oval in outline, mostly open ; vessel lines distinct to fairly conspicuous. *Soft tissues* or *parenchyma* distinctly visible to the eye, conspicuous under the lens arranged in broad wavy or fairly straight tangential bands,

slightly narrower than or about the same width as the somewhat darker fibre-layers between them. *Rays* of two sizes, broad to moderately broad and fine, the former distinct and sometimes very prominent to the eye being of the same width as or wider than the pores, particularly in *S. coccinea*, *S. colorata* and *S. fulgens*, widely spaced, forming a farily conspicuous fleck on the radial surface and the latter very few and visible only under the lens, not storied. *Ripple marks* indistinct or faint often just a suggestion due to the storied arrangement of the parenchyma which usually show secondary seriation. *Gum ducts* of the traumatic type, arranged in tangential rows have been observed in some specimens of *S. coccinea* and *S. fulgens*.

Strength—Out of the 5 species included here only a small consignment of narikel (*S. alata*) has been tested at Dehra Dun. For strength figures please see appendix I.

Seasoning—*S. alata* can be seasoned easily without much degrade. However, it should be converted soon after felling and open-stacked under cover so as to prevent discoloration.

Natural durability—Not at all durable in exposed situations.

Insect and fungus attack—Both logs and converted timber of *S. alata* and *S. colorata* are susceptible to various types of insect attack and damage chiefly by shot-hole borers, pin-hole borers and powder-post beetles. They are also easily subject to sap stain and discoloration. White spongy rot caused by *Polystictus occidentalis* Klotsch, and *Trametes corrugata* (Pers.) Bres. and honey-comb rot due to *Fomes lamaoensis* Murr. have been observed in *Sterculia alata*.

Preservative treatment—No tests have so far been carried out. But the timbers should be easy to treat.

Working qualities—*S. alata* is easy to work both with hand and machines and finishes to a better surface than any of the other species of *Sterculia*.

Supply and uses—Moderate supplies of *S. alata* are available from Assam and from the west coast forests of Mysore and Kerala. A good timber of its class; it is used chiefly for light packing cases, and plywood. It has also been found moderately suitable for both match-boxes and splits. Recently, trials carried out at Dehra Dun have shown that chemical pulp from this wood could be used for writing and printing papers.

Material—

S. alata—4563 Saharanpur, U.P. (0·42), 4732 Travancore (0·62), 6205 Dehra Dun, U.P. (0·44), 6441 Burma (0·48); 7650 Halsugaon, Assam (0·60).

S. coccinea—573 Darjeeling terai (0·28), 5464 Assam (0·26).
S. colorata—1394 Chittagong (0·37).

S. fulgens—6336 Burma (0·37).

S. populifolia—5607 Madras (0·42).

Description of the wood

(*Sterculia angustifolia*, *S. guttata*, *S. ornata* and *S. villosa*)

(Pl. 28, 165)

General properties—Sapwood and heartwood not distinct, wood pale yellowish or greyish-white to light greyish-brown, often discoloured ; extremely soft to soft and often spongy and easily dented with a finger nail ; extremely light to light (sp. gr. 0·16–0·46 air-dry) ; somewhat lustrous on the quarter-sawn or radial surface ; straight-grained and even and coarse-textured.

Gross structure—All are diffuse-porous woods. *Growth rings* indistinct to distinct, marked by a line of soft tissue, about 2–8 per cm. *Pores* large to moderately large occasionally of medium-size or smaller, few to moderately few (2–9 per mm.^{2}), more or less evenly distributed, solitary or in short radial multiples of 2–3, occasionally in small clusters of 3–5, rounded to oval in outline, open or sometimes filled with tyloses ; vessel lines distinct to fairly prominent. *Soft tissues* or *parenchyma* not visible to the eye, but distinctly visible under the lens, in numerous, fine, closely spaced, interrupted or broken lines across the rays, forming a sort of fine, irregular reticulm, sometimes tending to be diffuse ; also round the pores but not clearly defined. *Rays* of two sizes, very broad to moderately broad and fine, the former conspicuous to the eye, the largest being of the same width or even winder than the pores, widely spaced, forming a conspicuous fleck on the radial surface up to 5 mm. in height, and the latter very few, visible only with a lens, not storied. *Ripple marks* not visible to the eye, indistinct or faint even under the lens, often not more than a suggestion, due to the storied arrangement of the parenchyma which usually shows secondary seriation. *Gum ducts* usually traumatic, arranged in tangential bands, observed in some specimens of *S. guttata*, *S. ornata* and *S. villosa*.

Strength—None of these woods have been tested for strength. However, as they are all very soft and light they appear to be of poor strength and in this respect very much inferior to *S. alata*.

Seasoning—*S. villosa* can be seasoned easily without much degrade, cracking and warping being entirely absent. The timber is, however, liable to stain. Quick conversion and stacking in open under cover are recommended to avoid discoloration.

Natural durability—Easily perishable.

Insect attack—Easily attacked by insects in logs and converted timber, damage due to shot-hole and pin-hole borers and powder-post beetles being fairly common. One specimen of *S. guttata*, one of *S. ornata* and two of *S. villosa*, in the Dehra Dun collection show borer attack.

Preservative treatment—No information is available.

Working qualities—*S. villosa* is very easy to saw and work both with hand and machines, but rather difficult to bring to a good finish.

Supply and uses—West Bengal and Assam can supply fairly large quantities of *S. villosa*, while moderate supplies are available from the west coast forests of Mysore and Kerala and also from the Andamans and Burma. The timber is chiefly used for light packing cases. It has also been tested for match manufacture, but yields splints and boxes of poor quality. *S. ornata* from Burma being extremely light (sp. gr. 0·16–0·23 air-dry), might be tried as a substitute, for balsa, which it resembles in many respects.

Material—

S. angustifolia—6356 Burma (0·47).

S. guttata—4677 Travancore (0·22).

S. ornata—4850 Pyinmana, Burma (0·23), 5012 Thaystmyo, Burma (0·22), 5073 Thaungyin, Burma (0·20), 5103 Toungoo, Burma (0·17), 6805 Burma (0·16).

S. villosa—620 Darjeeling terai (0·25), 847 Kanara (0·28), 2324 Darjeeling terai (0·32), 4854 Burma (0·36), 6234 Dehra Dun (0·22), 6481 Burma (0·32), 7262 Kurseong (0·23), 7329 Jalpaiguri (0·32), 7449 Jalpaiguri (0·16), 7522 Chittagong (0·29), 7581 Jalpaiguri (0·23).

Description of the wood

(*Sterculia foetida* and *S. urens*)

(Pl. **28**, 164)

General properties—Sapwood greyish-white to pale pinkish buff, 4–6 cm. wide ; heartwood distinct, reddish-brown, soft to moderately hard ; light to moderately heavy (sp. gr. 0·41–0·67 air-dry): rather dull with a distinct oily feel and somewhat pungent odour when freshly cut ; straight-grained ; even and coarse-textured.

Gross structure—A diffuse-porous wood. *Growth rings* indistinct to fairly distinct, delimited by a line of soft tissue, 3–8 per cm. *Pores* visible to the eye, large to moderately large and few, but not infrequently medium-sized or smaller and moderately few to moderately numerous in *S. urens*, more or less evenly distributed, solitary or in short radial multiples of 2–3, with a tendency to be arranged in small rounded multiples or clusters of 3–5 particularly in *S. urens*, more rounded than oval in outline, with abundant tyloses in the heartwood ; vessel lines visible to the eye, but not conspicuous. *Soft tissues* or *parenchyma* indistinct to visible under the lens delimiting the growth rings but predominantly diffuse or in fine closely-spaced, interrupted or broken tangential

lines, often with broader bands at irregular intervals in *S. urens*. *Rays* of two sizes broad to moderately broad and fine, the former prominent to the eye, the largest of about the same width as an average sized pore, widely spaced, forming distinct but not conspicuous flecks on the radial surface, usually not more than 2–3 mm. in height and the latter very sparse, visible only under lens, not storied. *Ripple marks* not present or indistinct, but secondary seriation due to storied arrangement of parenchyma is sometimes seen particularly in sapwood of *S. urens*. *Gum canals* not observed in *S. foetida*, but often found in *S. urens* forming long uniseriate tangential rows, usually traumatic.

Strength—The timbers have not been tested for strength and as such no reliable figures are available. However, judging from their weight and hardness they appear to be stronger than other sterculias with the possible exception of *S. alata*.

Seasoning—Heartwood of *S. urens* is easy to season being not liable to warping and cracking. The sapwood however is susceptible to stain and should be converted immediately after felling in the dry season.

Natural durability—Sapwood of *S. urens* is very perishable but the heartwood is fairly durable under cover. According to Reyes, *S. foetida* is very perishable when exposed to the weather or in contact with the ground, but very durable for interior work.

Insect and fungus attack—Logs and converted timber of *S. urens* are liable to be attacked by borers, but the damage appears to be confined mainly to the sapwood. In the two specimens in the Dehra Dun Collection which show insect damage, only the light-coloured sapwood was found to be attacked, the darker reddish-brown heartwood being singularly free. The sapwood is also liable to stain and discoloration due to fungus attack.

Preservative treatment—No data available. But according to Pearson and Brown "there can be little doubt that the timber (*S. urens*) would readily absorb an antiseptic". While this may be true of the sapwood it may not hold good for the heartwood, where all vessels are heavily clogged with tyloses, both in *S. urens* and *S. foetida*.

Working qualities—Both are easy to saw and work and finish well.

Supply and uses—Supplies of *S. urens* are limited as this tree is found growing scattered in the forest, chiefly in Central India and the Deccan. *S. foetida* is confined only to the west coast, where it is used locally. The former according to Troup is used for doors of huts, dug-out canoes, boat-planking, guitars and carved toys. It is also said to be used for inferior packing cases and boards in Madras. It was tested for matches, but was found to yield splints and boxes of poor quality. *S. foetida* is also used for similar purposes as, *S. urens*, chiefly inferior buildings, dug-outs, rough packing cases and

cheap plywood. According to Reyes it is used in the Philippines for general house construction particularly sidings, ceilings and partitions.

Material—

S. foetida—5513 Burma (0·16), 7822 Coimbatore (0·67).

S. urens—471 Ajmere (0·48), 1102 Ahiri (0·59), 3436 Palamau (0·41), 6277 Burhampur, M.P. (0·57), 6402 Palghat (0·63).

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K. RAMESH RAO.

19. TILIACEAE

The family *Tiliaceae* excluding the *Elaeocarpaceae*, which is considered separately, consists of approximately 35–40 genera and about 400 species of trees and shrubs and rarely herbs, having a wide distribution throughout the tropical and temperate regions of the world. The anatomical structure of the woods of the genera described here resembles that of the *Malvaceae*, *Bombacaceae* and *Sterculiaceae*, more closely than that of the genera included under the *Elaeocarpaceae*.

The economic importance of the family is more due to the valuable bast fibres obtained from some genera, than on account of timber. *Corchorus capsularis* L. and *C. olitorius* L., are the source of the well known jute fibre of commerce from which gunny and hessian are made. The inner bark of some species of *Grewia*, *Erinocarpus* and *Triumfetta* yields a fibre used for cordage and rope making, while the fruits of some grewias are edible. The bark, roots, leaves and fruits of various species of *Grewia* are used in indigenous medicine, particularly for dysentery and other stomach disorders. From the standpoint of timber, perhaps the best known is the temperate genus *Tilia* which furnishes the well-known bass-wood of America and the lime or linden of Europe. Danta (*Cistanthera papaverifera* A. Chev.), which is sometimes exported from West Africa, is somewhat similar to yellow birch and is used for tool handles and carriage-building. Other well-known timbers are *thitka* or Burma mahogany (*Pentace burmanica* Kurz.), *dhaman* (*Grewia tiliaefolia* Vahl.) and Trincomalee wood (*Berrya ammonilla* Roxb.), all of which are found in the Indian region.

The family is represented in India by about ten or so genera of which eight are woody and attain tree size. Six genera, for which wood specimens were available for examination, are considered here. Of the remaining two, *Pityranthe verrucosa* Thw. – *dikwenna* (Sinh.), *vidpani* (Tam.) is a tree of Ceylon and yields a strong, tough wood, much in demand for axles of carts. *Trichospermum kurzii* King is a small to medium-sized tree up to 18 m. in height, found in the Nicobar islands.

The woods of most of the genera described here, show considerable variation in their general properties and anatomical structure and can usually be separated without much difficulty from one another. They range in colour from pale yellowish or pinkish-grey and light brown to dark reddish-brown or chocolate, and are soft to very hard, light to very heavy (sp. gr. 0·50–1·07 air-dry) dull to rather lustrous with attractive ribbon figure, fairly straight to somewhat interlocked-grained and medium to fine-textured. They are usually diffuse-porous, but sometimes may be semi-ring-porous in *Erinocarpus*

and some species of *Grewia*, and even distinctly ring-porous as in *G. pilosa*. Pores usually moderately large or medium-sized to small, few to moderately numerous, evenly distributed except in *G. pilosa*, mostly solitary and in radial multiples of 2–3 or more, rarely in clusters of 3–8, usually open, but completely filled with tyloses in *Berrya* and only partly so in *Pentace* and *G. tiliaefolia*. Soft tissues or parenchyma predominantly paratracheal in *Grewia*, *Erinocarpus* and *Berrya*, forming narrow vasicentric sheaths in *Grewia*, aliform to aliform-confluent with tendency to form irregular wavy bands in *Erinocarpus*, and in distinct tangential bands in *Berrya*; predominantly apotracheal in *Brownlowia*, *Columbia* and *Pentace* occurring as fine, closely spaced interrupted or broken lines forming a sort of reticulum occasionally tending to be diffuse. Rays mostly fine and regularly storied giving rise to distinct ripple marks in *Berrya*, *Brownlowia* and *Pentace*, while in the remaining genera, viz., *Columbia*, *Erinocarpus* and *Grewia*, they are of two distinct size classes, moderately broad and fine, the latter only somewhat irregularly storied or tending to be storied giving rise to rather faint and not very distinct ripple marks, often just a suggestion.

Key to the genera

1. Soft tissues, mainly vasicentric, paratracheal zonate or in straight or wavy tangential bands... 2

1. Soft tissues predominantly apotracheal, in fine, closely spaced, interrupted, tangential lines forming a reticulum, and also diffuse ... 5

    2. Wood ring-porous ... ... *Grewia* (*G. pilosa*)

    2. Wood diffuse-porous, to semi-ring-porous ... 3

3. Rays fine, all storied giving rise to distinct ripple marks. Wood very hard, very heavy, dark reddish-brown ... ... *Berrya*

3. Rays moderately broad and fine, only latter tend to be storied giving rise to faint and irregular ripple marks. Wood moderately hard, moderately heavy, usually light coloured ... 4

    4. Soft tissues round the pores mostly aliform to aliform-confluent, sometimes forming irregular wavy bands ... ... *Erinocarpus*

    4. Soft tissues round the pores, mostly vasicentric, forming a narrow sheath ... *Grewia* (excluding *G. pilosa* and *G. microcos*)

5. Rays, fine, storied, giving rise to distinct ripple-marks ... ... ***Brownlowia Pentace*

5. Rays, rather broad and fine, only latter somewhat irregularly storied, giving rise to faint ripple-marks ... ... ***Columbia, Grewia* (*G. microcos*).

1. BERRYA Roxb.

A small tropical genus of trees containing four species, all of which are confined to the Indo-Malayan region and Polynesia. Only one species *B. ammonilla* Roxb. occurs in the Indian region and is described here.

B. ammonilla Roxb. [**B. cordifolia** (Willd.) Burret]—trincomalee wood. *mai-long, mai-tonghu, petwun* (Burm.), *halmilla* (Sinh.), *chavandalai, kamba-maram, thirukkanamallay* (Tam.), *sarala devadaru* (Tel.). A large tree 18–27 m. in height, 2–2·5 m. in girth with a clear bole of 9–11 m., often fluted. *Bark* brownish-grey, rather smooth with longitudinal fissures, thin. It is found in the beach forests of the Andamans, and throughout Burma from the Shan hills to Pegu Yomas and Martaban up to 600 m. It is also fairly common in Ceylon. Though said to be found in Malabar and Travancore it is never seen there in the wild state and is probably only planted. Outside the Indian region, it occurs in the Philippines and Cochin-China and is also cultivated in the Malay Peninsula, Java, West Africa and Hawaii.

Description of the wood

(Pl. **28**, 166)

General properties—Sapwood whitish to light greyish-brown, heartwood dark reddish to chocolate-brown, often with darker streaks ; very hard, heavy to very heavy (sp. gr. 0·79–1·02 air-dry) ; rather dull with a somewhat oily feel and a characteristic odour when freshly exposed, often showing partridge mottling ; slightly interlocked-grained ; medium to rather fine-textured.

Gross structure—A diffuse porous wood. *Growth rings* distinct to indistinct, when distinct clearly visible to the naked eye, delimited by darker bands of fibrous tissue with comparatively fewer pores and scanty soft tissues. *Pores* moderately large to moderately small, fairly distinct to just visible to the eye, moderately numerous (10–20 per $mm.^2$) but fewer in the darker bands of fibrous tissue, solitary or in radial multiples of 2–5, mostly 2–3, occasionally in small clusters, round to oval in outline, abundantly plugged with tyloses ;

* *Pentace*, though closely resembling *Brownlowia* can often be distinguished from it by its usually interlocked-grain and more prominent ripple marks. *Columbia* is usually softer, lighter and somewhat coarser-textured than *G. microcos* and has more prominent rays.

vessel lines not very conspicuous, but distinct on the longitudinal surfaces as light coloured or whitish scratches against the darker background. *Soft tissues* or *parenchyma* round the pores and also connecting them by fine, fairly straight or wavy tangential bands, distinct under lens, but just visible or indistinct to the eye on account of their comparatively dark colour. *Rays* fine to very fine not visible to the eye, visible under lens but not sharply defined, being of only a slightly lighter colour than the background, less than 0·5 mm. in height, storied. *Ripple marks* present, barely visible to the naked eye, distinct under lens, fairly regular and well defined, about 32–37 per cm.

Strength—It is a strong tough timber with high shock resistance. For strength figures please see appendix I.

Seasoning—For a timber of its weight and hardness it seasons fairly well and is not usually subject to serious splitting. Surface cracks are, however, liable to develop especially towards the centre of broad planks.

Natural durability—A first class exceptionally durable timber, even in exposed situations, with an average life of over twenty years.

Insect attack—Only outer sapwood is subject to borer attack, and is, therefore, generally removed during conversion.

Preservative treatment—Not so far treated, but does not appear to require any treatment for practically all purposes.

Working qualities—Difficult to saw, but machines well and works to a good finish taking high polish. If flat-sawn judiciously, gives highly decorative boards with handsome partridge mottling. Though somewhat interlocked-grained, it splits clean and straight in the tangential plane.

Supply and uses—Large supplies are available from Burma, while the Andamans can probably supply only a small quantity. It is an ideal timber where durability, strength and elasticity are called for, and is, therefore, suitable for carriage and cartmaking (spokes, shafts and bent parts), agricultural implements and tool handles. It is a good timber for building and general construction and is also used for boat building, particularly for sampans, masula boats and heavy oars. It is much in demand for oil-casks and barrels. Though decorative, it is rather heavy for ordinary furniture, but makes into nice bentwood walking-sticks and might do well for bentwood furniture.

Material—

288 Burma (0·79), 327 Burma (1·02), 1452 Burma (0·95), 1420 Burma (0·96), 2722 Burma (0·95), 3118 Burma (0·82), 5275 Burma (0·89), 5276 Burma (1·03), 5292 Burma (1·07), 5293 Burma (0·98), 5294 Burma (0·86), 5295 Burma (0·95), 5793 Burma (1·02).

2. BROWNLOWIA Roxb.

A tropical Asiatic genus of trees comprising about 10 species. Of the three species known to occur in the Indian region only *B. elata* Roxb. is described here as no wood specimens were available for the other two species. *B. lanceolata* Benth. – *bola sundri, kedar* sundri (Beng.) – is a small tree or large shrub of the tidal and mangrove forests of the Sundarbans, Chittagong, Burma coast and the Andamans, while *B. peltata* Benth. is a small tree of Tenasserim.

B. elata Roxb.—*maj, majot, masjat, mosse* (Beng.) is a large tree often reaching a girth of 3–4·5 m., found frequently associated with sundri (*Heritiera* spp.) in the tidal forests of the Sundarbans, Chittagong and Tenasserim.

Description of the wood

(Pl. **28**, 167)

General properties—Wood light reddish or greyish-brown; moderately hard; moderately heavy (sp. gr. 0·70 air-dry); not lustrous; straight-grained and medium to fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, 2–4 per cm. delimited by darker bands of fibrous tissue. *Pores* medium-sized to small, just visible to the eye, moderately numerous (14–20 per $mm.^2$), evenly distributed, mostly in short radial multiples of 2–4, also solitary, round to oval in outline, usually open; vessel lines visible on the longitudinal surfaces, but rather fine and inconspicuous. *Soft tissues* or *parenchyma* not visible to the eye, distinct under lens, diffuse to diffuse-aggregate and in fine, closely-spaced, interrupted, tangential lines forming an irregular reticulum with the rays. *Rays* rather fine, scarcely visible to indistinct to the eye, but distinct under lens, evenly spaced, fairly close, forming a rather dull darker coloured fleck on the radial surface, the largest about a mm. in height, mostly storied. *Ripple marks* present, fairly distinct to the eye, as well as under lens, about 30 per cm.

No data regarding strength, working qualities and other properties are available. The wood, however, closely resembles that of *Pentace* and *Pterospermum*. It is said to be locally used for beams and scantlings, and may prove suitable for furniture, planking and packing cases.

Material—

1951 Chittagong (0·70).

3. COLUMBIA Pers.

A small genus of trees and shrubs confined to tropical Asia. Three species occur in the Indian region of which only one *C. floribunda* Wall. is described

here. *C. flagocarpa* C. B. Clarke is a small to medium-sized tree of Chittagong hill-tracts and *C. merguensis* Planch. is a small tree or shrub of Mergui in Burma for which no wood specimens were available for study.

C. floribunda Wall. [**Colona floribunda** (Kurz) Craib]—*larubanda* (Asm.), *dwabok, magan, petshat, petwaing* (Burm.), *bra-ragang-phang* (Kach.), *anthathing* (Kuki), *thaltre* (Lush.), *arlak-pi* (Mik.), *khasre* (Nep.). A shrub or small to medium-sized tree up to 15 m. in height and 90 cm. in girth with fluted trunk. *Bark*, grey and rough outside, cream-coloured or reddish-brown inside, finely fibrous, 8–12 mm. thick.

It occurs as a medium-sized tree in Assam growing more or less gregariously in Sibsagar, Nowgong, Lushai hills, North Cachar hills and Naga hills. In Burma, it is usually much smaller, either a shrub or small tree and is found in Martaban hills and Shan hills.

Description of the wood

(Pl. 28, 168)

General properties—Wood oat-meal or light brown in colour; soft; light (sp. gr. 0·53 air-dry); somewhat lustrous; straight-grained and medium-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct on all the three surfaces, sharply delimited by the darker and very much denser latewood, with somewhat smaller pores, about 1–2 per cm. *Pores* moderately large to small, somewhat smaller in the latewood, rather few to moderately numerous (4–15 per mm.^{2}), evenly distributed, mostly solitary and in short radial multiples of 2–4, sometimes in small clusters of 3–6 particularly in latewood, round to oval in outline, usually open; vessel lines distinct on longitudinal surfaces but not conspicuous. *Soft tissues* or *parenchyma* not visible to the eye, not quite distinct even under lens, appearing as fine, short, broken lines between adjacent rays, forming an indistinct reticulum. *Rays* of two distinct size classes, broad to moderately broad and fine; the former sometimes as wide as the average sized pore, distinctly visible to the eye and prominent under lens, few, widely spaced not storied; the latter visible only under lens, numerous, closely spaced and somewhat irregularly storied. *Ripple marks* present, visible to the eye, but not well defined under lens, about 25–30 per cm.

No information regarding strength, seasoning and other properties is available. The single specimen examined, however, showed a tendency to split along the broad rays. Being soft and straight-grained, it should be easy to work and may prove suitable for packing cases.

Material—

6410 Burma (0·53).

4. ERINOCARPUS NIMMO EX J. GRAH.

A monotypic genus of trees confined to South India.

E. nimmonii Grah.—*adivi bhendy, kad bende* (Kan.), *chira, chor, choura, haladi* (Mar.). A medium-sized tree. *Bark* grey or brown, smooth, but with narrow longitudinal clefts, fibrous, about 10 mm. thick. It is found in the Deccan, Konkan and Kanara in the mixed monsoon forests of the Western Ghats.

Description of the wood

(Pl. 29, 169)

General properties—Wood pale yellowish-brown; moderately hard; moderately heavy (sp. gr. 0·72 air-dry); not lustrous; straight-grained; medium-textured.

Gross structure—A diffuse-porous to semi-ring-porous wood. *Growth rings* distinct, delimited by somewhat denser latewood with smaller pores and a more or less continuous line of soft tissue, 2–6 per cm. *Pores* moderately large to small, visible to the eye, somewhat large in the early wood and gradually tending to be smaller in the latewood, moderately few to rather numerous (8–25 per $mm.^2$), somewhat unevenly distributed, being usually more numerous in latewood, mostly solitary and in radial multiples of 2–3 occasionally up to 5, rarely in tangential pairs or small clusters, round to oval in outline; vessel lines distinct on longitudinal surfaces but not conspicuous. *Soft tissues* or *parenchyma* just visible to the eye, distinct under lens, mostly round the pores as "haloes" or "eyelets" often connecting adjacent pores and sometimes forming irregular wavy bands; also in fine tangential bands delimiting growth rings. *Rays* of two sizes, moderately broad and fine; the former distinctly visible to the eye, prominent under lens, few and widely spaced up to 2–3 mm. in height but not conspicuous on the radial surface, being of the same colour as the background; the latter visible only under lens, more closely spaced, about 3–6 between the broader rays with a slight tendency towards storied arrangement. *Ripple marks* just a suggestion.

There is no information regarding strength and other physical properties of this timber. It is said to be used locally for rafters, house-building and yokes.

Material—

5378 South Thana, Bombay (0·72).

5. GREWIA L.

(including *Microcos* L.)

A large tropical and sub-tropical genus of over 150 species of trees and shrubs, having a wide distribution in Africa, Asia and Australia. More than

30 species are found in India of which only six are included here. Apart from minor variations in colour, hardness and weight, the woods described are more or less similar and cannot always be distinguished with certainty from one another, except for *G. pilosa* Lam. and *G. microcos* L. (*Microcos paniculata* L.). The former a large straggling shrub, shows typically ring-porous structure. The latter has been placed by Burret in separate genus *Microcos* L. which from anatomical point of view, appears to be in order. Besides the six species considered here, wood specimens of *G. orbiculata* Rottler, *G. populifolia* Vahl [*G. tenax* (Forsk) Aschers & Schwf.] and *G. salvifolia* Heyne (*G. daminae* Gaertn.) – all shrubs of arid regions were also available for examination and were found to be similar in structure to the other diffuse-porous grewias.

Key to the species

1. Soft tissues predominantly apotracheal, in fine, closely spaced, interrupted, tangential lines running from ray to ray ... ... *G. microcos*
1. Soft tissues predominantly paratracheal, in narrow vasicentric sheaths round the pores ... 2
   2. Wood distinctly ring-porous ... ... *G. pilosa*
   2. Wood mostly diffuse-porous, rarely semi-ring-porous 3
3. Pores usually filled with tyloses or chalky white deposits. Wood reddish-brown to dark brown with darker streaks ... ... *G. tiliaefolia*
3. Pores usually open. Wood pale yellowish-grey to light yellowish-brown ... ... **G. elastica*, *G laevigata*, *G. oppositifolia*.

1. **G. elastica** Royle—*bijol-goch*, *man-bijal*, *phuhura* (Asm.), *pengtarow*, *pintayo* (Burm.), *pharson* (Dotial), *pharsanyi*, *pharsawon* (Garhwal), *khengkhriwakbik* (Garo), *dhamma* (Jharua, Garo hills), *bimla*, *dhaman*, *pharsia* (Hind.), *laiman-phang*, *mikir-lata-phang*, *thai-a-dou* (Kach.), *dieng-sohlanghri-that*, *dieng-tha-ballich* (Kh.), *gonyer* (Kol.), *thai-girip-theng* (Kuki), *pharsuli* (Kumaon), *kunsung* (Lep.), *pershuajelah*, *thusura* (Mechi.), *dhamia*, *hasa-dhamin* (Merwara), *bong-der-so-arong*, *the-bong-dar-arong* (Mik.), *sialphosra* (Nep.), *poto-dhamun* (Palamau), *dhamman*, *farri*, *phalwa* (Punj.), *nanhaolat* (Sant.). A small to medium-sized tree usually 6–12 m. in height and 60–90 cm. in girth, with a clear bole of 3–6 m. In favourable localities, as in

* Quite often it is possible to distinguish *G. elastica* from the other two on account of its slightly coarser texture and usually streaky appearance due to denser and darker latewood bands, which show rather prominently on longitudinal surface. *G. oppositifolia* is the finest textured among the Grewias described here and is also usually harder and somewhat heavier than *G. laevigata*.

Assam, it attains a larger size reaching up to 18 m. in height and about 1·5 m. in girth. *Bark* greyish-white outside, exfoliating in rectangular flakes, whitish inside with pink streaks, turning brown.

It is found in the sub-Himalayan tract from the Indus eastwards to Bengal, in Chota Nagpur, Madhya Pradesh, Assam and Burma ascending up to 900 m.

Description of the wood—See page 235.

2. G. laevigata Vahl—*bulaw-shaw, kwe-tayaw, kyet-tayaw, tayaw* (Burm.), *bolmengu* (Garo), *bhimul, kakki, katbhewal, kath-bimla* (Hind.), *khau-khlem-maising-phang, khau-khlem-marsi, kithang-samjia* (Kach.), *gurguri, javanigalle, kaori* (Kan.), *dieng-doh-thli, dieng-tiew-sat, dieng-tiew-ser* (Kh.), *gara bursu* (Kol.), *gulgollop* (Konkani), *thing-nhap-khir, wai-thel-te-thing* (Kuki), *dali-bhimal* (Kumaon), *dhansagla* (Lep.), *kokur-sida* (Mechi), *rampak-arong, senam-longda, theng-rom-pa* (Mik.), *kaki* (Or.), *marang jowar* (Sant.), *gan-ghthi* (Sylhet), *anaikatti-maram, narathai* (Tam.), *allpeyar, thegalle* (Tel.), *patat* (Tharu). A small to medium-sized tree up to 14 m. in height and about a metre in girth. *Bark* dark grey or brown outside with vertical reticulations, cream-coloured inside, thin.

It is found in the outer Himalayas from the Jumna eastwards to Bengal, in Chittagong, Assam, central and southern India, the Andamans and Burma, ascending up to 900 m.

Description of the wood—See page 235.

3. G. microcos L. (Microcos paniculata L.)—*pisoli* (Asm.), *asar, aswar* (Beng.), *myat-ya, mya-ya, myinka-hpan, thayoh* (Burm.), *bolchibins, borsubret* (Garo), *koipura, lakhul-guta, pipi* (Jharua), *dieng-soh-dkhar, dieng-soh-liong-hadem* (Kh.), *tarah* (Magh), *kotta* (Mal.), *heitup* (Manipur), *asolin, pachawi, shirul* (Mar.), *theng-pranke-arong* (Mik.), *keliya, kohu-kirilla* (Sinh.), *pesondi, phisindia* (Sylhet), *kottei* (Tam.). Very variable in habit, usually, a small to medium-sized tree up to 12–15 m. in height and 1–1·5 m. in girth, with a clear bole of 3–8 m., often fluted, at times only a shrub. *Bark* dark brown to almost black outside, exfoliating in small thin flakes, pink or reddish and fibrous inside, about 6 mm. thick.

It is found in the evergreen forests of the Western Ghats from Konkan southwards, in the hills of Assam up to 600 m. in Chittagong, the Andamans and throughout Burma. It also occurs in Ceylon, Cochin-China, Java and Sumatra.

Description of the wood

(Pl. 29, 172)

General properties—Wood light greyish-buff to pale pinkish or reddish-brown ; moderately hard ; moderately heavy (sp. gr. 0·70–0·71 air-dry) ; somewhat lustrous ; straight-grained and medium-fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* fairly distinct, usually visible only under the lens, delimited by somewhat denser and slightly darker latewood, 1 to 3 per cm. *Pores* just visible to the eye, medium-sized to small, moderately few to moderately numerous (6–20 per mm.^{2}), evenly distributed, mostly solitary and in radial multiples of 2–3, rarely in longer multiples or clusters of 3–6, usually oval in outline and open. *Soft tissues* not visible to the eye, but fairly distinct under the lens, predominantly apotracheal, in fine, closely-spaced, very much interrupted or broken tangential lines, running from ray to ray, occasionally tending to be diffuse. *Rays* apparently of two sizes, moderately broad to fine and very fine; the former often just visible to the eye but not very distinct, being of the same colour as the background, fairly widely spaced, not at all storied; the latter barely visible even under the lens, rather closely spaced and somewhat indistinctly storied. *Ripple marks* present, fairly distinct to rather faint and irregular, sometimes just a suggestion, usually seen better with the naked eye than under lens, about 24–28 per cm.

No reliable information regarding strength, seasoning and other properties is available. However, the timber of the closely allied Philippine species described by Reyes under *Microcos stylocarpa* (Warburg) Burret, is reported to be "moderately strong; seasons well but susceptible to sap stain; works and finishes very well; not durable when exposed to the weather or in contact with the ground" and is said to be used for general construction and agricultural implements. In physical properties and structure the Indian timber closely resembles *Pterospermum* spp., and may prove suitable for packing cases and plywood.

Material—

6293 Burma (0·71), 6627 Burma (0·70).

4. G. oppositifolia Roxb. ex Mast.—*bahul, behel, bewal, bhengal, bhimal, biul, biung* (Hind.), *biur* (Jaunsar), *bhiunl* (Kumaon), *dhamman, pharan, pharwa* (Punj.), *katar* (Pushtu). A small to medium-sized tree, 9–12 m. in height and about a metre in girth, with a clear bole of 3–4 m. *Bark* grey, smooth.

It occurs throughout the north-western Himalayas ascending up to 1,800 m. and extending eastwards to Nepal. It is fairly common in the Punjab and Uttar Pradesh.

Description of the wood—See page 235.

5. G. pilosa Lam. (G. flavescens Juss.)—*posangni, ghor-dhaman* (Berar), *kirkali* (Kan.), *gursikri* (Kharwar), *bhorkund* (Monghyr), *parangan, pasangan, phiongli, pisangan* (Rajputana), *sitarga* (Sant.), *karichli* (Tam.), *tegali* (Tel.). A large straggling shrub with sharply 3 to many angled or conspicuously fluted stem. *Bark* grey, smooth 2–3 mm. thick on the ridged portions, elsewhere papery thin.

It occurs chiefly in the dry regions of Rajputana, Bihar and the Deccan, ascending up to 1,100 m. in West Khandesh.

Description of the wood

(Pl. **29**, 174)

General properties—Wood divided into triangular wedges due to the deeply fluted or sharply 4–5 angled shape of the stem; yellowish-brown; moderately hard; moderately heavy (sp. gr. 0·64 air-dry); straight-grained; rather coarse and uneven-textured.

Gross structure—A distinctly ring-porous wood. *Growth rings* distinctly marked by a broad belt of large pores in the early wood, 7–8 per cm. *Pores* large to small, unevenly distributed, early wood pores large to moderately large, distinctly visible to the eye, mostly solitary and in radial, oblique or tangential pairs; latewood pores small to very small, visible only under the lens, mostly in clusters of 3–8; usually rounded and not infrequently filled with tyloses; vessel lines distinct. *Rays* fine to very fine, visible only under the lens, fairly closely spaced, the shorter ones tending to be storied. *Ripple marks* present - very faint and irregular, indistinctly seen only in latewood.

The wood is not much in demand, but the branches are used locally for making baskets.

Material—

5390 Chanda (0·64).

6. **G. tiliaefolia** Vahl.—**dhaman**. *damnak* (Bhil.), *pintayaw, tayaw* (Burm.), *pharsai* (Garhwal), *aintu, baranda kasul, khosla* (Gon.), *dhamana* (Guj.), *dhaman, dhamin, phalsa, pharsa* (Hind.), *batala, butale, tadasal, thadsal* (Kan.), *dhaman* (Kharwari), *kehelmohru* (Khond), *ahsing, dhaman, gonyer, goyar, marar* (Kol), *pharsia* (Kumaon), *dhamni* (Kurku), *chadache, chadicha, sadachu* (Mal.), *daman, dhamani* (Mar.), *kultho* (Mayurbhanj), *bhangia, dhamani, dhamono, dhamuro* (Or.), *tara* (Palkonda), *jangolat, olat* (Sant.), *daminiya* (Sinh.), *chadachchi, charachi, unam, unu* (Tam.), *charachi, jana, tharra* (Tel.). Usually a medium-sized tree up to 12 m. in height and 1–1·5 m. in girth, with a straight cylindrical bole of 4·5–6 m. In favourable localities as in Malabar, Kanara and Coorg it attains a larger size over 2 m. in girth, with a 9 m. clear bole. Very large trees, however, may often be faulty at the centre. *Bark* pale grey in young trees, dark or blackish-brown in old trees, rough and fibrous, peeling off in small flakes, 1–2 cm. thick.

It is found in the sub-Himalayan tracts from the Jumna to Nepal throughout central and southern India ascending up to 1,200 m. and is rather common in the Western Ghats, particularly, Coorg and Wynaad where it reaches its

best development. It also occurs in upper Burma and the low country of Ceylon below 450 m.

Description of the wood—See below.

Description of the wood

(*Grewia elastica, G. laevigata, G. oppositifolia* and *G. tiliaefolia*)

(Pl. 29, 170, 171, 173 ; Pl. 30, 175)

General properties—Sapwood pale yellowish-white to yellowish-grey to light greyish-brown in *G. tiliaefolia*, distinct from the heartwood, which is reddish-brown to brown with darker coloured streaks ; wood pale yellowish-grey to light yellowish-brown in others with characteristic darker streaks in *G. elastica* ; a small, light reddish-brown centre was observed in one specimen of *G. oppositifolia* ; somewhat soft to moderately hard and light to moderately heavy (sp. gr. 0·50–0·60 air-dry) in *G. laevigata*, but moderately hard to rather hard and moderately heavy to heavy (sp. gr. 0·67–0·88 air-dry) in others, dull, sometimes with a faint smell mildly suggestive of teak in *G. tiliaefolia*, but fairly lustrous in others with a somewhat unpleasant odour in *G. oppositifolia*, especially when freshly cut ; fairly straight-grained and medium to medium-coarse-textured in *G. elastica* and *G. tilaefolia*, and medium-fine to rather fine-textured in *G. laevigata* and *G. oppositifolia*.

Gross structure—All are diffuse-porous woods with occasional semi-ring-porous tendency in some specimens, particularly of *G. tiliaefolia*. *Growth rings* distinct, delimited either by narrow, light coloured lines of soft tissue as in *G. laevigata* and *G. oppositifolia* or by denser and darker latewood portions, which often show up as distinct dark-coloured streaks on the longitudinal surface as in *G. elastica* and *G. tiliaefolia*, 2–5 per cm. *Pores* fairly distinct to just visible to the eye, moderately large or medium-sized to small in *G. elastica* and *G. tiliaefolia*, and usually small to very small in *G. laevigata* and *G. oppositifolia*, mostly moderately few to moderately numerous (6–19 per mm.^{2}) but often rather numerous (20–30 per mm.^{2}) in *G. oppositifolia* ; evenly to somewhat unevenly distributed, mostly solitary or in short radial multiples of 2–3, occasionally in clusters of 3–5 or more, often round rather than oval in outline, usually open except in *G. tiliaefolia*, where they are filled with tyloses or chalky white deposits ; vessel lines distinct in *G. elastica* and *G. tiliaefolia*, somewhat less distinct or just visible in *G. laevigata* and *G. oppositifolia*. *Soft tissues* predominantly paratracheal, visible under the lens as narrow vasicentric sheaths or haloes round the pores, sometimes also with a little diffuse parenchyma, which is indistinct or barely visible even under lens, as in *G. elastica* and *G. tiliaefolia* ; also usually forming fairly distinct narrow layer delimiting the growth rings in *G. laevigata* and *G. oppositifolia*. *Rays* apparently of two size classes, moderately broad to fine and very fine, the largest in the former class

visible to the eye, the latter visible only under lens, fairly wide apart to rather closely spaced ; the small rays comparatively few with just a tendency to storied arrangement in *G. tiliaefolia*, and indistinct or somewhat irregularly storied in *G. elastica* and *G. laevigata*, relatively numerous and distinctly storied in *G. oppositifolia*. *Ripple marks* present, due to the storied arrangement of small rays and longitudinal elements, rather faint and indistinct, often just a suggestion in *G. tiliaefolia*, more distinct in the others, particularly in *G. oppositifolia*, 35–45 per cm.

Strength—Excepting *G. laevigata* all others have been tested at the Forest Research Institute, Dehra Dun. For strength figures please see appendix I.

Seasoning—*G. tiliaefolia* is a moderately refractory timber, though liable to surface cracking and end-splitting during air seasoning. Conversion of logs, soon after felling and proper stacking under shade give good results. The other three species also have a tendency to develop surface cracks and end-splits, while *G. elastica* and *G. laevigata* are very liable to warp as well. In all cases green conversion and open-stacking under cover are recommended for satisfactory results in air seasoning.

Natural durability—The timber of *Grewia tiliaefolia*, though reputed to be very durable in the open, was found in actual graveyard tests at Dehra Dun to be only moderately durable, with an average life of 6 years, the minimum being 5 years and the maximum just under 10 years. The others are not at all durable in exposed situations, but fairly so under cover.

Insect and fungus attack—Newly felled logs of *G. tiliaefolia* are liable to be attacked by shot-hole borers – *Xyleborus noxius* and *X. testaceus* Wek, while the sapwood when mostly dry is subject to powder-post damage. All the four timbers when dry are liable to be attacked by the borer beetle – *Stromatium barbatum* Fab. Besides sap rot caused by *Schizophyllum commune* Fr., white spongy-rot due to *Daedalea flavida* Lév., and *Ganoderma applanatum* (Pers.) Pat., and white rot as a result of attack by *Fomes fastuosus* Lév., have been recorded on *G. tiliaefolia*.

Preservative treatment—Heartwood of *G. tiliaefolia* is refractory to treatment, incision being necessary for 1–2 cm. penetration. The others should be more amenable to treatment.

Working qualities—*G. tiliaefolia* and *G. elastica* present no difficulty in sawing and machining. They are both easy to work and finish and lend themselves well to turning. The former can be peeled though not an economical proposition for plywood. *G. oppositifolia* is somewhat difficult to saw and work with hand, while *G. laevigata* does not finish to a good surface.

Supply and uses—By far the largest supplies of *G. tiliaefolia* (*dhaman*) are from the south zone – chiefly the Coorg and Kanara forests of Mysore. Moderate supplies are available from the north zone, while the central zone

could supply small quantities. The timbers of other *Grewia* spp., are also often known as *dhaman*, and are available in fair quantities from the north and east zones, while the supply is rather limited in the central and west zones. Being strong, elastic and tough, *dhaman* (*G. tiliaefolia*) is used extensively, where these qualities are called for, as in agricultural implements, axe-helves and tool-handles, picker arms, oars, for shafts, felloes and spokes in cart construction, motor-lorry bodies and buses, camp furniture, military tent-poles, golf shafts, billiard cues, etc. It is also suitable for general construction, particularly for door and window frames, carriage building and furniture. It has been tried and found very suitable for both slack and tight cooperage, being excellent for cement barrels and making really good beer kegs comparing favourably with those of English oak. With proper precautions in seasoning and selection it might do for various types of shuttles, bobbins, pirns, reels and textile mill accessories. *G. elastica* being almost as strong and perhaps as little tougher could perhaps be used with satisfactory results, for most purposes for which *G. tiliaefolia* has been found suitable. According to Troup, *G. oppositifolia* is also locally used for shoulder poles, axe handles, bows, oars and other purposes requiring toughness and elsticity. *G. laevigata*, which is somewhat lighter and softer is not of much commercial value even locally, but perhaps might be tried for cheap turnery, cement barrels and rough packing cases.

Material—

G. elastica – 651 Darjeeling terai (0·67), 2325 Darjeeling terai (0·77), 3120 Burma (0·77), 5679 Siwaliks (0·66), 5951 Motichur, U.P. (0·69), 6052 Dehra Dun, U.P. (0·71).

G. laevigata – 4835 Dehra Dun, U.P. (0·50), 6230 Dehra Dun, U.P. (0·60).

G. oppositifolia – 154 Sainj, Simla (0·73), 6051 Dehra Dun, U.P. (0·76).

G. tiliaefolia – 188 Mandla, M.P. (0·76), 1169 M.P. (0·86), 1253 Ganjam (0·80), 3818 Ganjam (0·88), 5723 Kanara (0·73), 5753 Kanara (0·73), 5876 Raipur, M.P. (0·76), 7497 Madras (0·75), 7498 Madras (0·69), 7499 Madras (0·79), 7503 Madras (0·71).

6. PENTACE HASSK.

A tropical genus of about 15–20 species of trees confined mostly to Malaya and Burma but does not grow in India proper. Two species occur in Burma and are described here. The woods of these two species are very similar in appearance and structure and cannot be distinguished from each other.

1. **P. burmanica** Kurz—Burma mahogany, thitka. *kashit, kathitka, takothet, thethet, thitka* (Burm.). A very large, tall tree reaching in favourable

localities a height of about 40 m. with a clear bole of 20–23 m. and a girth of of 1·5–2·5 m. It is found in the tropical forests of Burma, in Pyinmana, the Pegu Yomas, Martaban and Tenasserim.

Description of the wood—See below.

2. **P. griffithii** King—*thitkale, thitso* (Burm.). A large, much buttressed tree of the forests of Tavoy in lower Burma.

Description of the wood—See below.

Description of the wood

(*Pentace burmanica* and *P. griffithii*)

(Pl. 30, 176)

General properties—Sapwood and heartwood not sharply defined, gradually merging into each other ; wood usually light reddish-brown, turning darker on exposure sometimes with a yellowish-grey tinge ; moderately hard ; usually moderately heavy (sp. gr. 0·55–0·74 air-dry), but slightly heavier in *P. griffithii* ; rather lustrous often showing ribbon or roe figure when quarter-sawn ; usually interlocked-grained and medium-textured.

Gross structure—Both are diffuse-porous woods. *Growth rings* fairly distinct to indistinct ; when distinct usually demarcated by darker and denser latewood, occasionally also by a somewhat interrupted to more or less continuous line of soft tissue, 2–6 per cm. *Pores* moderately large to small, visible to the eye, distinct under lens, moderately numerous to numerous (11–32 per mm.^{2}), evenly distributed, mostly solitary or in radial multiples 2–3, occasionally more, or in small clusters, round to oval in outline, partly filled with tyloses ; vessel lines distinct on the longitudinal surfaces, but not conspicuous. *Soft tissues* not visible to the eye, distinct under lens as fine, light-coloured closely-spaced interrupted or dotted tangential lines connecting adjacent rays and forming a net-like structure with them, also diffuse and scattered ; occasionally in somewhat interrupted to more or less continuous lines delimiting growth rings. *Rays* fine, indistinct or not visible to the eye, distinct under lens, evenly and rather closely spaced forming low but distinct dark flecks on the radial surface less than 0·5 mm. in height, prominently storied. *Ripple marks* present, very conspicuous, distinct to the eye as well as under lens, 23–30 per cm.

Strength—Both *P. burmanica* and *P. griffithii* have been tested at Dehra Dun, the former on a limited scale, as only a small consignment was available. For strength figures please see appendix I.

Seasoning—Thitka is not a refractory timber to season, with no marked tendency towards warping or splitting. Though rather slow to dry, if properly stacked and protected it is reported to air season without much difficulty. It

can also be kiln seasoned satisfactorily with little degrade other than slight tendency to check and warp.

Natural durability—Both species are very durable under cover and durable in exposed situations, giving an averrge life of 13–14 years in actual graveyard tests at Dehra Dun.

Insect attack—The wood of both the species appears to be little liable to insect attack. None of the 13 specimens in the Dehra Dun collection showed any insect damage.

Preservative treatment—Tests carried out at Dehra Dun, show that heartwood of thitka is refractory to treatment, incision being necessary for even 1–2 cm. penetration.

Working qualities—Thitka is easy to work both by hand and with machines. However, due to interlocked-grain and the consequent tendency to picking up, quarter-sawn boards require some care in bringing to a good surface. The timber takes stain and polish well, and when quarter-sawn gives a handsome stripe or roe figure. It has also fairly good nailing, screwing and glueing properties.

Supply and uses—Considerable supplies of Burma mahogany or thitka (*Pentace burmanica*) are available from Burma, the chief ports of extraction being Rangoon, Moulmein and Tavoy. It is a high quality timber, similar in many respects to the true mahogany (*Swietenia* spp.) of the West Indies and South America. It is extremely decorative when judiciously sawn, and is ideally suited for high class furniture, cabinet making, interior fittings and panelling and makes up into good walking sticks and mathematical instruments. It is used in boat-building particularly sampans, for planking, gunwhale, stringers, masts and oars. It has also been tried on a small scale in railway coaches particularly for repair work and appears quite suitable for the purpose. The wood of *P. griffithii* closely resembles Burma mahogany and though considered slightly inferior to it may be used for practically the same purposes.

Material—

P. burmanica – 280 Burma (0·64), 802 Burma (0·63), 815 Burma (0·70), 1386 Burma (0·63), 2915 Burma (0·65), 3119 Burma (0·58), 5764 Burma (0·55), 6172 Burma (0·70), 6293 Burma (0·60), 7096 Burma (0·69).

P. griffithii – 6385 Burma (0·74), 7081 Burma (0·72), 7082 Burma (0·67).

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K. RAMESH RAO.

20. ELAEOCARPACEAE

This family is placed by some botanists under *Tiliaceae*. It consists of about 7–10 genera and over 120 species of shrubs and trees, distributed in the tropics and sub-tropics of both the old and new world. The anatomical structure of the wood of the genera described here is distinct from that of the *Tiliaceae* and justifies their being treated separately.

The family is not of much economic value, from the point of view of timber as well as other products. The fruits of some species of *Elaeocarpus* (*E. serratus* L., *E. lanceaefolius* Roxb., *E. varunna* Ham. and *E. floribundus* Blume) and *Aristotelia* are edible and may be pickled or eaten in curries. The hard tubercled stones from the fruits of *E. ganitrus* Roxb., and *E. tuberculatus* Roxb. are cleaned and polished and used as beads for rosaries, necklaces, bracelets and other ornamental objects. The fruits as well as the bark and the leaves of a number of species of *Elaeocarpus* are of medicinal value. The three genera *Elaeocarpus*, *Sloanea* and *Echinocarpus* yield timbers of local importance only. 'White or silver quandong' (*Elaeocarpus grandis* F. v. M. and *E. kirtonii* F. v. M.) and 'blush carrobean' (*Sloanea australis* F. v. M.) of Australia are the best known timbers and are used for decorative and stained cabinet work. Though the timbers are mostly soft to moderately hard and easy to work, some species of *Sloanea* from the West Indies produce very hard, very heavy and strong timber known as 'Sloane's green-heart' or break-axe'. The Australian 'ebony-heart of Cairns' obtained from *Elaeocarpus bancroftii* F. v. M. et Bail is also very hard and heavy somewhat resembling 'lignum vitae'. The wood of the South American *Aristotelia maqui* L. Her., though too small to be of commercial importance, is said to resemble basswood.

Only two genera, *Echinocarpus* Blume and *Elaeocarpus* L., are represented in India and are described here. The woods are mostly light-coloured, soft to moderately hard, light to moderately heavy and easy to work. They are featured anatomically by small pores, which are usually in radial multiples of 2–4 or more and by rays of apparently of two sizes. Soft tissues are not visible even under hand lens in *Echinocarpus* and some specimens of *Elaeocarpus*.

The two genera have so similar wood that they can not always be separated with certainty by their gross structure. However, the presence of a somewhat continuous line of soft tissue delimiting the growth rings in many specimens of *Elaeocarpus*, serves to distinguish them from *Echinocarpus*. The latter also has a somewhat smaller pores and a finer texture.

1. ECHINOCARPUS BLUME

A small genus of trees containing about a dozen species, confined mostly to South-East Asia and Australia. Five species are known to occur in India

of which three are described here. *E. sterculiaceus* Benth. – *thabola* (Magh), *saimuladdi* (Mechi), *banj* (Nep.), is a very large tree of Bhutan, Sikkim and hills of Martaban and Tenasserim, while *E. tomentosus* Benth. – *taksor* (Lep.), *kaktay, runche* (Nep.), is a medium-sized to large tree of Bhutan, Sikkim and Khasi hills from 600–1,200 m. For both these no wood samples were available for study. The timbers of the three species studied are practically similar in all respects and can not, therefore, be distinguished from one another.

1. **E. assamicus** Benth. (Sloanea assamica Rehd. et Wils.)—*sibe-taba, tane-asing* (Abor), *bandor-kadoi, jaba-hingori, phul-hingori* (Asm.), *sinta, sita* (Cachar), *tophen-changne* (Duff.), *phaithing* (Kuki), *sarang* (Mechi), *phong-rong-arong* (Mik.), *sibe-taba, sibe-tatar* (Miri), *thing-patkhui* (Tippera), is a moderately large tree up to 18 m. in height and over 1·5 m. in girth, often buttressed at the base. *Bark* blackish to greyish with white blotches, fairly smooth, thin.

It is a common tree throughout Assam occurring more or less gregariously on river banks. It is also found in Sikkim.

2. **E. dasycarpus** Benth. [Sloanea dasycarpa (Bth.) Hemsl.]—*taksol* (Beng.), *be-it-kung, taksol* (Lep.), *gobri, gobria* (Nep.), is a large tree, with a straight but buttressed trunk. *Bark* dark grey.

It grows at elevations from 1,500–2,400 m. in Bhutan and Sikkim in the eastern Himalayas and also occurs in Khasi and Naga hills in Assam from 1,100–1,500 m. It is also found in China.

3. **E. sigun** Blume (Sloanea sigun K. Schum)—is a large tree of Khasi hills and Burma, found growing at elevations from 900–1,500 m. It also occurs in Cambodia and Java.

Description of the wood

(*Echinocarpus assamicus, E. dasycarpus* and *E. sigun*)

(Pl. 30, 177)

General properties—No colour distinction between sapwood and heartwood of any of the specimens examined ; wood cream coloured to light yellowish-grey to greyish-brown, sometimes with pinkish tinge, often discoloured with dirty greyish-brown or black streaks ; soft ; very light to light (sp. gr. 0·32–0·51 air-dry) ; somewhat lustrous with slight silver fleck on radial surface ; straight-grained ; rather fine and even-textured.

Gross structure—A diffuse-porous wood. *Growth rings* distinct, demarcated by darker coloured bands of denser latewood fibres, 2–5 per cm. *Pores* small to very small, indistinct to the eye, moderately numerous to numerous (16–42 per mm.^{2}), evenly distributed, mostly solitary or in radial multiples of 2–3, rarely more or in clusters, rounded to oval or somewhat angular in outline, usually open, occasionally filled with tyloses ; vessel lines inconspicuous or just

visible on the longitudinal surfaces. *Soft tissues* not visible to the eye or even under hand lens. *Rays* apparently of two types, moderately broad to fine and extremely fine, the former visible to the eye, few and widely spaced and the latter indistinct to just visible under hand lens, very closely spaced.

Strength—None of the timbers has been tested for mechanical strength. They are as a rule soft and somewhat weak and appear to be of the same class as *semul*.

Seasoning—According to Pearson and Brown, the timber (*E. dasycarpus*) stains rapidly and is somewhat liable to warp. Green conversion and open stacking as well as kiln seasoning are recommended for good results. The same remarks will perhaps apply to the other two species described in this book.

Natural durability—The timber (*E. dasycarpus*) perishes rapidly in exposed situations and is only moderately durable under cover.

Insect attack—Freshly felled logs of *E. dasycarpus* are liable to attack by shot-hole borers.

Working qualities—Easy to saw and work giving a fairly smooth surface.

Supply and uses—Only limited supplies are available locally in W. Bengal and Assam. The timbers are all used for planking and packing cases. *E. dasycarpus* has been tried for match manufacture and found fairly satisfactory for both splints and boxes.

Material—

E. assamicus – 6809 Burma (0·43), 7248 Lakhimpur, Assam (0·32), 7602 Lakhimpur, Assam (0·34), 7629 Lakhimpur, Assam (0·33).

E. dasycarpus – 694 Darjeeling (0·51), 5131 Bengal (0·50), 6110 Darjeeling (0·45).

E. sigun – 6636 Burma (0·31).

2. ELAEOCARPUS L.

A large genus of trees comprising well over a hundred species the majority of which are distributed in the Indo-Malayan region. The genus, however, is spread over a wide area being also represented in Madagascar, Socotra, Cochin-China, the Philippines, Formosa, the Pacific islands, Australia and New Zealand. About 25 species occur in the Indian region of which only 13, for which wood specimens were available for study, are included here. Excepting minor variations in colour, hardness and weight, the woods of these species are not distinguishable from one another.

1. **E. braceanus** Watt—A small tree with warty bark, found in Naga hills and Khasia and Jaintia hills in Assam up to 1,500 m., Manipur and Kachin hills in upper Burma.

2. **E. ferrugineus** Bedd. (E. recurvatus Carner)—*solabikki* (Kan.). A medium-sized tree about 12 m. in height with a clear bole of 3 m. and a girth of about 90–120 cm.

It occurs in the forests of the Western Ghats, in the Nilgiris, Anamalais, Pulney hills as well as the high hills of Travancore at 1,800–2,400 m.

3. **E. floribundus** Blume—*belphoi, jalpai* (Asm. and Beng.), *banghkri, mai-mamon-pan, thitpwe* (Burm.), *badar-phang* (Kach.), *ron* (Kuki), *charphal* (Manipur), *ok-hi-siming-ti, theng-koreng-arong* (Mik.), *koying* (Nep.). A medium-sized tree usually 9–12 m., clear bole 3–4·5 m. and about 90–150 cm. in girth, but some times up to 18 m. and a girth of 2·4 m. *Bark* greyish-brown, vertically fissured often with horizontal wrinkles.

It is found in North Bengal, Sikkim and Assam, up to 1,500 m. and also occurs in Chittagong and the tropical forests of Martaban hills and Tenasserim in lower Burma up to 900 m.

4. **E. ganitrus** Roxb. [E. sphaericus (Gaertn.) K. Schum.]—*ludurai-asing* (Abor.), *rudai, rudrai, rudraksh* (Asm.), *rudrakhya* (Beng.), *ludrok, udrok* (Garo), *rudrak, rudraksh* (Hind.), *soh-lang-skei* (Kh.), *van-tha-mu-thing* (Kuki), *lekam-arong* (Mik.), *boragi-asing* (Miri). A medium-sized to large tree attaining a height of about 18 m. (clear bole 9–12 m.) and a girth of 1·2–1·5 m., usually buttressed at the base. *Bark* greyish-brown, fairly smooth with slight reticulate fissures, 6–12 mm. thick, fibrous inside.

The tree is found in Nepal, Assam, North Bengal, Chittagong and Tenasserim and also grows in Malay Peninsula, Java and Celebes.

5. **E. lacunosus** Wall.—*bankhri, butalet* (Burm.), is a medium-sized tree 12–15 m. in height (clear bole 3–6 m.) and 90–120 cm. in girth, but usually with a crooked trunk. *Bark* dark grey, somewhat rough and striated.

It is widely distributed in Burma in the tropical evergreen and moist upper mixed forests of Pegu and Martaban down to Tenasserim.

6. **E. lanceaefolius** Roxb.—*sakalang* (Asm.), *banghkri, budalet* (Burm.), *shipkyew* (Lep.), *dieng-sohkhyllam* (Kh.), *batrachi, bhadras* (Nep.), *dieng-soh-lyngka* (Synteng), is a large tree up to 30 m. in height (clear bole 6–12 m.) and 2·4–3·7 m. in girth. *Bark* greyish-brown and wrinkled, outside light red and fibrous inside.

It occurs chiefly in the eastern Himalayas from 1,800–2,400 m., Khasi hills, Manipur and Tenasserim and also found to some extent on the Eastern Ghats.

7. **E. robustus** Roxb. [E. tectorius (Lour.) Poir.]—*panonaku* (Andamans), *huara, poreng, seleng* (Asm.), *hminkya, kayahmwe, kyeng-lwai, mailim,*

taumagyi (Burm.), *agong, bol-ragong, gangmai, ragong* (Garo), *bon-khong-krai-phang, muga-phang, songrung-baphong* (Kach.), *dieng jaroi, dieng-lasaw, dieng-soh-khyllam* (Kh.), *chekio* (Magh), *theng-phrang-ki-arong* (Mik.), *tehei-chi-ching* (Naga), *batrachi, bepari* (Nep.). A moderate-sized to fairly large tree 12–18 m. high and 90 cm.–1·8 m. in girth, often buttressed at the base. *Bark* greenish grey and fairly smooth in young stems, but rough and warty in older trees, fibrous inside.

It is found in the eastern Himalayas up to 600 m., in Sikkim and North Bengal, and also in Assam, Chittagong, the Andamans and the Malay Peninsula.

8. **E. rugosus** Roxb.—*taruk-pai-asing* (Abor and Miri), *bor-chopa, gat-ronga, phul-champa* (Asm.), *sanku-nuru* (Duff.), *ankhi-si-phak* (Garo), *bon-lai-su-phang* (Kach.), *kadeng-srang-arong* (Mik.), *nundekhi* (Nep.). A large tree usually 18–24 m. in height and about 1·8–2·4 m. in girth, but may sometimes attain a height of 30 m. or even more and a girth of as much as 4·3 m. *Bark* grey, rather smooth to somewhat striated or wrinkled outside, 6–8 mm. thick.

It is found in Assam, Chittagong and the tropical forests of Pegu Yomas, and Martaban in Burma.

9. **E. serratus** L.—*changbale, kumbang* (Kan.), *kara-mavu, nalla-kara, valia-kara* (Mal.), *karai, karamaram, olan-karai* (Tam.). A medium-sized to fairly large tree up to 18 m. in height and about 1·2–1·5 m. in girth. *Bark* dark grey, smooth, inner bark dark brown fibrous, 8–19 mm. thick.

It occurs chiefly in the evergreen forests of the Western Ghats up to 1,500 m. from North Kanara southwards and is also found in Ceylon.

10. **E. stapfianus** Gagnep. Syn. *E. simplex* Kurz—A medium-sized tree of Assam and Burma.

11. **E. tuberculatus** Roxb.—*bhutali, danala, kadambola* (Kan.), *ammak-karam, badraksham, koda vasi, naggara, navadi, pilahi, pulanthi, rudraksham* (Mal.), *malam-pinnai-patrachi, rudracham, rutthracham* (Tam.). A large tree about 24 m. in height and 2·1 m. in girth, buttressed at the base. *Bark* dark coloured, mottled and rough outside, yellowish inside.

It is found commonly in the evergreen forests of the Western Ghats and adjoining hills in Bombay, Madras, Mysore, Coorg and Travancore-Cochin up to 1,500 m.

12. **E. varunna** Ham.—*taruk-pai-asing* (Abor and Miri), *bhadraik, bhadraksha, gangma-chiring, niganibual, poreng, saulkuri, tuttcaly* (Asm.), *gangma-chiring* (Garo), *dieng-ri-lam, dieng-sia-sah* (Kh.), *mir-chobe* (Mik.), *pong-o-test* (Naga), *bhadrax* (Nep.). A fairly large tree up to 15 m. in height and about 1·8 m. in girth. *Bark* grey or brownish-grey nearly smooth or lightly fissured.

It occurs in the sub-Himalayan tract from Nepal eastwards ascending up to 1,200 m. and is also found in Assam and Chittagong.

13. E. wallichii Kurz—*bamo, waso* (Burm.). A large tree 18–21 m. high with a clear bole of 9 m. or more and a girth of 90 cm.–1·8 m. *Bark* greyish-brown, rather smooth, 8 mm. thick.

It is found chiefly in the eng forests of lower Burma, from Martaban down to upper Tenasserim and along the base of the Pegu Yomas. It also occurs in Goalpara in Assam.

Description of the wood

(*Elaeocarpus braceanus, E. ferrugineus, E. floribundus, E. ganitrus, E. lacunosus, E. lanceaefolius, E. robustus, E. rugosus, E. serratus, E. stapfianus, E. tuberculatus, E. varunna* and *E. wallichii*)

(Pl. 30, 178–180)

General properties—Wood whitish, pale straw to greyish-brown to olive, occasionally purplish grey with a pinkish tinge (*E. floribundus*) ; heartwood observed only in two specimens of *E. robustus* and *E. tuberculatus*, darker than the sapwood, well defined ; soft to moderately hard ; light to moderately heavy (sp. gr. 0·40–0·71 air-dry) ; somewhat lustrous, straight-grained to somewhat curly or wavy-grained, sometimes giving rise to handsome fiddle-back figure (*E. robustus* and *E. tuberculatus*) ; medium to fine-textured.

Gross structure—A diffuse-porous wood. *Growth rings* well defined to indistinct in the same species, sometimes in the same specimen ; when distinct, demarcated by denser fibrous tissue or more or less continuous line of soft tissue or both. *Pores* moderately large to small, fairly distinct to just visible to the eye, moderately few to numerous (5–40 per mm.^{2}), mostly solitary or in radial multiples of 2 to 4, sometimes more, up to 7, rounded to oval in outline, usually open or sparsely filled with tyloses ; vessel lines visible on the longitudinal surfaces fairly distinct to inconspicuous. *Soft tissues* fairly distinct to indistinct, when distinct, forming a fine more or less continuous line delimiting the growth rings. *Rays* apparently of two sizes, medium-sized to fine and extremely fine, the former just visible to the eye on the end surface, widely spaced and the latter visible only with lens, numerous, closely spaced. *Pith flecks* observed in a number of specimens.

Strength—Only *E. tuberculatus* has been tested at the Forest Research Institute, Dehra Dun. For strength figures please see appendix I.

Seasoning—Not difficult to season, though *E. ferrugineus* and *E. lanceaefolius* are somewhat liable to end crack. *E. robustus* and *E. tuberculatus* are not at all refractory, but the latter is easily susceptible to discoloration and stain especially if kept in the log. Green conversion and open stacking under cover are recommended. Kiln seasoning of green timber should also give satisfactory results.

Natural durability—Not durable in exposed situations but fairly so under cover.

Insect attack—Both logs and converted timber are susceptible to attack by shot-hole and pin-hole borers.

Preservative treatment—No tests have been carried out but should not be difficult to treat.

Working qualities—Easy to saw, working to an even surface without difficulty. According to Swain and Boas, 'white quandong' (sp. gr. 0·44–0·50) of Australia produced by *E. grandis* and *E. kirtonii* holds nails well and takes glues and stain satisfactorily while straight-grained timber is ideal for bending. The Indian species being similar may do equally well.

Supply and uses—Excepting *E. tuberculatus* supplies are limited and are available only locally. Moderate supplies of *E. tuberculatus* are available from the south zone, while the supplies of the same timber from the west zone are limited. The woods are all locally used for planking and light packing cases. Carefully selected figured stock of some species, showing fiddle-back mottling, should prove valuable for decorative furniture and cabinet making. *E. lanceaefolius* and *E. tuberculatus* have been tried for match manufacture and found fairly satisfactory. Logs from the Andamans have peeled and sliced well.

Material—

E. braceanus – 6824 Burma (0·59).

E. ferrugineus – 6124 Ootacamund (0·71).

E. floribundus – 6686 Burma (0·68).

E. ganitrus – 4878 Sylhet (0·45), 5524 Darrang, Assam (0·40), 5541 Kamrup, Assam (0·40).

E. lacunosus – 6693 Burma (0·53).

E. lanceaefolius – 358 Darjeeling (0·57), 5132 Bengal (0·56), 6113 Darjeeling (0·53).

E. robustus – 581 Darjeeling terai (0·57), 6056 Balugau, Orissa (0·62), 7813 Andamans (0·53), 7821 Andamans (0·56).

E. rugosus – 6736 Burma (0·54), 7121 Burma (0·56).

E. serratus – 4612 Travancore (0·49).

E. stapfianus – 6261 Tavoy, Burma (0·55).

E. tuberculatus – 6125 Palghat (0·47), 6743 Burma (0·46), 7582 Palghat (0·50), 7636 E. Kanara (0·48).

E. varunna – 4887 Assam (0·42).

E. wallichii – 6690 Burma (0·66).

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K. RAMESH RAO.

APPENDICES

APPENDIX I.—*Mechanical*

Serial No.	Name of species	Locality from where tested	Specific gravity based on weight oven-dry and volume green	Weight per cu. metre at 12% m.c. in kg.	Shrinkage % green to oven-dry		
					Radial	Tangential	Volumetric
1	2	3	4	5	6	7	8
1	Anisoptera glabra ..	Insein, Burma	0·475	593	2·3	7·1	10·9
2	Balanocarpus utilis ..	Tinnevelly, Madras	0·844	993	4·8	8·2	12·6
3	Berrya ammonilla ..	Insein, Burma	0·772	961	5·5	9·5	15·8
4	Bombax insigne ..	S. Andaman	0·313	368	2·4	4·9	7·8
5	Bombax malabaricum	Dehra Dun, Uttar Pradesh	0·329	368	2·3	5·1	7·4
6	Calophyllum inophyllum ..	Madras	0·624 (Volume at test)	705	..	..	..
7	C. polyanthum ..	W. Bengal	0·682 (Volume at test)	769	..	..	..
8	C. tomentosum ..	Madras	0·516	609	5·1	6·7	13·8
9	C. tomentosum ..	S. Kanara, Mysore	0·546	657	4·9	6·6	12·8
10	C. wightianum ..	S. Kanara, Mysore	0·569	689	5·0	8·0	12·6
11	C. wightianum ..	Madras	0·641 (Volume at test)	721	..	..	..
12	Cullenia excelsa ..	Malabar, Kerala	0·532	625	4·3	6·9	11·2
13	Dillenia indica ..	Chittagong Hill tracts, E. Pakistan	0·524	641	3·2	8·7	13·7
14	D. pentagyna ..	Buxa, Bengal	0·531	625	3·0	7·5	10·8
15	Dipterocarpus alatus	Insein, Burma	0·574	673	3·6	8·6	14·3
16	D. bourdilloni ..	Kerala	0·577	705	4·5	9·6	15·5
17	D. costatus ..	Chittagong, E. Pakistan	0·704	849	..	..	13·3

1 kg./cu. m. = 0·0624 lb./cu. ft.; 1 kg./cm² = 14·2233 lbs./in.²; 1 cm. = 0·39370 inch; 22·68 kgs. = 50 lbs.

Properties of Woods

Condition	Static Bending		Impact Bending	Compression parallel to grain	REMARKS
	Modulus of Rupture kg. per cm.²	Modulus of Elasticity kg./cm.²	Max. height of drop of a 22·68 kg. hammer in cm.	Max. crushing stress, kg./cm.²	
9	10	11	12	13	14
Green ..	553·5	86,800	69	295·4	
Air-dry ..	747·7	100,500	97	390·7	
Green ..	1234·7	169,200	135	656·6	
Air-dry ..	1510·7	187,200	160	755·1	
Green ..	945·2	133,700	150	449·1	
Air-dry ..	1193·8	147,200	145	563·7	
Green ..	358·4	61,500	48	175·2	
Air-dry ..	499·3	67,200	43	273·8	
Green ..	382·0	51,000	53	180·9	
Air-dry ..	428·3	59,600	48	242·1	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (m.c. 11·5%)	765·6	70,300	..	519·6	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (m.c. 13·4%)	1046·2	95,500	..	574·1	
Green ..	664·4	102,200	71	360·8	
Air-dry ..	910·9	125,600	71	461·1	
Green ..	672·2	97,700	74	345·1	
Air-dry ..	921·0	120,200	51	571·9	
Green ..	672·7	86,800	89	349·5	
Air-dry ..	709·7	101,900	51	521·5	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (m.c. 12·6%)	1011·7	95,000	122	582·5	
Green ..	736·8	124,300	74	361·2	
Air-dry ..	1061·8	145,800	89	571·1	
Green ..	602·6	86,100	76	292·1	
Air-dry ..	947·9	119,500	79	488·0	
Green ..	591·5	75,700	56	285·0	
Air-dry ..	803·3	95,500	74	514·6	
Green ..	661·5	103,900	74	318·4	
Air-dry ..	1020·7	151,900	76	552·1	
Green ..	677·8	127,100	74	311·7	Small consignment.
Air-dry ..	1051·3	156,200	89	581·4	
Green ..	841·2	129,200	84	424·2	Small consignment.
Air-dry .. (m.c. 12·8%)	1127·6	149,600	94	550·5	

APPENDIX I.—*Mechanical*

Serial No.	Name of species	Locality from where tested	Specific gravity based on weight oven-dry and volume green	Weight per cu. metre at 12% m.c. in kg.	Shrinkage % green to oven-dry		
					Radial	Tangential	Volumetric
1	2	3	4	5	6	7	8
18	D. grandiflorus ..	North Andaman	0·606	753	4·0	11·5	19·1
19	D. indicus ..	S. Coorg, Mysore	0·618	753	6·0	11·4	18·9
20	D. kerrii ..	Burma	0·616	785	5·8	12·3	19·1
21	D. macrocarpus ..	Lakhimpur, Assam	0·595	721	5·2	10·3	17·6
22	D. obtusifolius ..	Burma	0·596	..	..	..	..
23	D. tuberculatus ..	Insein, Burma	0·726	849	4·4	9·1	14·0
24	D. turbinatus ..	Insein, Burma	0·655	769	4·2	8·9	15·0
25	Elaeocarpus tuberculatus ..	N. Mangalore, Mysore	0·403	465	3·1	6·1	9·4
26	Garcinia indica ..	Kanara, Mysore	0·637 (at 11% m.c.)	705	..	..	..
27	Garcinia speciosa ..	Burma	0·746	..	..	..	..
28	G. xanthochymus ..	Kanara, Mysore	0·873 (at 13·3% m.c.)	977	..	..	..
29	Grewia elastica ..	Kurseong, Bengal	0·606	753	5·4	9·5	16·0
30	Grewia oppositifolia ..	W. Pakistan	0·683	801	5·0	7·8	16·2
31	Grewia tiliaefolia ..	Malabar, Kerala	0·651	785	4·1	7·9	14·5
32	Heritiera fomes ..	Delta, Burma	0·792	1041	5·9	11·6	22·1
33	Hibiscus macrophyllus	Sibsagar Div., Assam	0·552	..	3·6	6·5	11·8
34	Hopea glabra ..	Palghat, Kerala	0·869	1073	4·3	8·7	12·4

Properties of Woods—(contd.)

Condition	Static Bending		Impact Bending	Compression parallel to grain	REMARKS
	Modulus of Rupture, kg. per cm.²	Modulus of Elasticity kg./cm²	Max. height of drop of a 22·68 kg. hammer in cm.	Max. crushing stress, kg./cm.²	
9	10	11	12	13	14
Green .. Air-dry ..	628·5 1015·6	117,100 151,300	74 76	317·4 542·5	
Green .. Air-dry ..	789·1 1245·2	162,900 201,400	71 112	411·1 719·4	
Green .. Air-dry ..	715·7 1281·1	136,200 186,000	84 109	324·3 601·8	
Green .. Air-dry ..	722·8 1209·1	133,400 170,400	69 112	353·6 636·6	
Green .. Air-dry .. (m.c. 11·9%)	708·4 1238·5	115,400 144,300	.. ..	362·5 495·5	
Green .. Air-dry ..	815·3 1197·7	123,300 156,400	102 112	396·7 567·2	Small consignment
Green .. Air-dry ..	774·9 1203·4	142,000 161,900	81 102	412·2 575·5	
Green .. Air-dry ..	483·7 656·9	87,400 98,600	58 56	253·0 381·1	
Green .. Conditioned .. (m.c. 11%)	.. 1018·5	.. 116,000	.. 81	.. 534·5	Small consignment.
Green .. Air-dry ..	1080·8 ..	124,900 ..	124 ..	627·3 ..	Small consignment.
Green .. Conditioned .. (m.c. 13·3%)	.. 1107·3	.. 137,500	.. 119	.. 644·7	Small consignment.
Green .. Air-dry ..	770·5 1122·0	120,000 152,800	142 163	363·6 560·5	
Green .. Kiln-dry .. (at 16·4% m.c.)	632·4 728·4	70,200 81,800	97 130	238·6 371·7	Small consignment.
Green .. Air-dry ..	912·9 1301·9	148,200 163,900	91 124	480·3 701·2	
Green .. Air-dry ..	820·1 1338·4	137,800 179,700	122 112	402·1 640·9	
Green .. Air-dry ..	845·9 ..	108,800 ..	109 ..	419·6 ..	Small consignment.
Green .. Air-dry ..	1067·3 1263·7	147,900 160,700	124 180	581·4 710·5	

APPENDIX I.—*Mechanical*

Serial No.	Name of species	Locality from where tested	Specific gravity based on weight oven-dry and volume green	Weight per cu. metre at 12% m.c. in kg.	Shrinkage % green to oven-dry		
					Radial	Tangential	Volumetric
1	2	3	4	5	6	7	8
35	Hopea odorata ..	S. Tenasserim, Burma	0·637	753	3·4	6·5	9·3
36	H. parviflora ..	S. Mangalore, Mysore	0·794	929	3·8	8·1	11·5
37	Kayea assamica ..	Lakhimpur, Assam	0·712 (at 15·4% m.c.)	801	..	..	..
38	Kydia calycina ..	Lakhimpur, Assam	0·347 (at 14·4% m.c.)	384	..	..	..
39	Mansonia dipikae ..	Rangapahar, Assam	0·577 (at 8·3% m.c.)	641	..	..	..
40	Mesua ferrea ..	Sibsagar, Assam	0·809	961	6·0	9·5	15·8
41	M. ferrea ..	S. Coimbatore, Madras	0·970 (Volume at test)	1089	..	..	..
42	M. ferrea ..	E. Kanara, Mysore	0·977 (Volume at test)	1089	..	..	..
43	M. ferrea ..	W. Bengal	0·904 (Volume at test)	1009	..	..	..
44	M. ferrea ..	Madras	1·002 (Volume at test)	1121	..	..	..
45	Michelia cathcartii ..	Kurseong, Bengal	0·455	529	3·7	6·9	13·2
46	M. champaca ..	Kurseong, Bengal	0·426	497	3·2	5·2	8·2
47	M. excelsa ..	Kurseong, Bengal	0·441	513	3·9	7·6	11·1
48	M. oblonga ..	Buxa Divn., Bengal	0·375	449	3·2	6·1	9·9
49	Miliusa velutina ..	Dehra Dun, Uttar Pradesh	0·626	753	4·8	9·3	..
50	Ochrocarpus longifolius	N. Kanara, Mysore	0·927 (Volume at test)	1041	..	..	..

Properties of Woods—(contd.)

Condition	Static Bending		Impact Bending	Compression parallel to grain	REMARKS
	Modulus of Rupture kg. per cu.	Modulus of Elasticity kg./cm.²	Max. height of drop of a 22·68 kg. hammer in cm.	Max. crushing stress, kg./cm.²	
9	10	11	12	13	14
Green ..	808·7	106,400	86	441·3	
Air-dry ..	963·9	117,400	74	471·8	
Green ..	927·8	130,300	94	528·9	
Air-dry ..	1353·7	145,100	127	692·9	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (15·4% m.c.)	1078·3	142,700	99	579·6	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 14·4% m.c.)	483·4	72,700	43	237·2	
Green ..	..	..	..	..	Small consignment.
Conditioned .. (at 8·2% m.c.)	1218·8	147,200	112	657·9	
Green ..	1166·0	163,000	130	621·2	
Air-dry ..	1716·3	203,000	142	884·5	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 13·9% m.c.)	1641·0	217,400	168	916·1	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 9·9% m.c.)	1971·4	226,000	..	1076·4	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 11·1% m.c.)	1666·3	162,000	..	869·7	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 14·5% m.c.)	1784·4	221,300	173	960·7	
Green ..	520·7	103,600	51	248·9	
Air-dry ..	862·9	136,600	69	396·3	
Green ..	563·0	83,900	66	282·6	
Air-dry ..	634·0	95,100	61	415·1	
Green ..	538·8	101,200	56	268·9	
Air-dry ..	801·2	115,700	58	423·7	
Green ..	397·4	71,000	71	178·9	
Air-dry ..	629·0	85,700	53	326·4	
Green ..	583·8	79,200	69	281·6	
Air-dry ..	767·2	93,200	56	476·6	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 11·3% m.c.)	1284·5	109,500	..	673·2	

APPENDIX I.—*Mechanical*

Serial No.	Name of species	Locality from where tested	Specific gravity based on weight oven-dry and volume green	Weight per cu. metre at 12% m.c. in kg.	Shrinkage % green to oven-dry		
					Radial	Tangential	Volumetric
1	2	3	4	5	6	7	8
51	Parashorea stellata ..	Tharrawaddy, Burma	0·589	721	4·2	9·8	14·3
52	Pentacme suavis ..	Pyinmana, Burma	0·779	913	4·8	8·9	14·2
53	Pentace burmanica ..	Burma ..	0·558	641	3·1	6·5	10·1
54	Pentace griffithii ..	Tavoy, Burma ..	0·725	865	5·1	8·4	13·0
55	Poeciloneuron indicum	N. Mangalore, Mysore	0·902	1121	8·5	10·4	18·9
56	P. indicum ..	S. Coimbatore, Madras	0·780 (Volume at test)	881	..	..	..
57	P. fragrans ..	Malabar, Madras	0·445	513	3·4	7·3	10·5
58	P. simiarum ..	Gauhati, Assam..	0·591	705	3·7	8·0	11·7
59	Pterospermum acerifolium ..	Buxa, Bengal ..	0·507	609	3·4	6·0	9·8
60	Saccopetalum tomentosum ..	E. Kanara ..	0·615	737	3·8	8·8	12·1
61	Sageraea listeri ..	S. Andaman ..	0·727	865	5·4	8·4	13·7
62	Schima wallichii ..	Buxa, Bengal ..	0·539	689	4·5	8·5	20·1
63	Shorea assamica ..	Lakhimpur, Assam	0·479	545	3·1	7·7	10·8
64	Shorea obtusa ..	Burma ..	0·858	1041	5·4	9·7	15·1
65	Shorea robusta ..	Balaghat, M.P. ..	0·684	801	4·0	8·4	13·2
66	Shorea robusta ..	Kalimpong and Jalpaiguri, Bengal	0·745	897	5·1	9·9	14·3
67	Shorea robusta ..	N. Kheri, Haldwani, Gorakhpur, Uttar Pradesh	0·753	881	4·2	8·8	11·8

Properties of Woods—(contd.)

Condition	Static Bending		Impact Bending	Compression parallel to grain	REMARKS
	Modulus of Rupture kg. per cm.²	Modulus of Elasticity kg./cm.²	Max. height of drop of a 22·68 kg. hammer in cm.	Max. crushing stress, kg./cm.²	
9	10	11	12	13	14
Green ..	716·0	134,600	76	385·3	
Air-dry ..	1029·6	156,600	81	591·0	
Green ..	902·0	141,500	102	480·5	
Air-dry ..	1179·8	164,100	81	561·7	
Green ..	762·6	104,500	84	407·1	Small consignment.
Air-dry ..	924·2	114,000	74	521·0	
Green ..	1074·8	164,800	119	575·4	
Air-dry ..	1436·0	182,600	142	715·2	
Green ..	1119·7	162,700	117	588·7	
Air-dry ..	1600·1	217,500	130	907·8	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 12·4% m.c.)	1508·1	204,800	112	756·5	
Green ..	538·8	92,000	56	280·1	
Air-dry ..	684·3	109,500	61	355·5	
Green ..	747·3	124,500	66	381·4	Small consignment.
Kiln-dry .. (12% m.c.)	1035·5	146,100	97	583·9	
Green ..	676·8	95,500	117	346·7	
Air-dry ..	955·7	116,900	107	435·1	
Green ..	740·4	110,600	89	387·2	
Air-dry ..	950·7	126,800	89	516·9	
Green ..	1075·1	150,000	155	501·6	
Air-dry ..	1722·4	168,700	173	783·9	
Green ..	555·4	95,700	79	265·8	
Air-dry ..	1084·2	145,000	69	580·7	
Green ..	553·9	92,700	76	284·5	
Air-dry ..	660·7	110,000	56	407·7	
Green ..	1005·6	164,400	117	578·1	
Air-dry ..	1523·5	193,600	112	746·9	
Green ..	842·6	126,700	102	423·1	
Air-dry ..	1064·2	140,400	97	543·3	
Green ..	981·7	150,100	114	493·8	
Air-dry ..	1368·4	172,000	140	594·1	
Green ..	981·9	127,900	117	480·3	
Air-dry ..	1061·4	132,200	119	586·5	

APPENDIX I.—*Mechanical*

Serial No.	Name of species	Locality from where tested	Specific gravity based on weight oven-dry and volume green	Weight per cu. metre at 12% m.c. in kg.	Shrinkage % green to oven-dry		
					Radial	Tangential	Volumetric
1	2	3	4	5	6	7	8
68	Shorea robusta ..	Haldwani, Uttar Pradesh	0·736	881	4·2	8·9	13·2
69	Shorea robusta ..	Kurseong, Bengal	0·735	881	4·0	10·3	14·1
70	Shorea robusta ..	Ramnagar, Uttar Pradesh	0·728	865	4·0	9·1	13·8
71	Shorea robusta ..	Jalpaiguri, Bengal	0·737	913	4·5	9·3	14·1
72	Shorea robusta ..	Gorakhpur, Uttar Pradesh	0·707	833	3·7	8·4	13·5
73	Shorea robusta ..	Kurseong, Bengal	0·768	897	4·3	10·0	14·5
74	Shorea robusta (Valley type). ..	Saranda, Bihar	0·721	849	4·6	9·1	13·5
75	Shorea robusta (Hill type). ..	Saranda, Bihar	0·718	833	3·8	9·1	12·6
76	Shorea robusta ..	Kalagarh, Uttar Pradesh	0·700	849	4·0	8·2	13·8
77	Shorea robusta ..	N. Kheri, Uttar Pradesh	0·726	849	3·6	8·1	11·9
78	Shorea robusta ..	Bengal	0·769	897	3·9	9·0	13·0
79	Shorea robusta ..	Kachugaon, Assam	0·700	833	4·3	9·8	14·1
80	Sterculia alata ..	Assam	0·475	593	2·9	7·0	10·2
81	Sterculia campanulata	Insein, Burma	0·282	320	2·0	5·9	7·7
82	Thespesia populnea ..	Kolaba Divn., Bombay	0·647	769	3·8	6·9	10·0
83	Vateria indica ..	N. Mangalore, Mysore	0·483	577	3·4	10·4	14·3
84	Vateria macrocarpa ..	Palghat Divn., Kerala	0·482 (Volume at test)	545	..	..	..
85	Vatica lanceaefolia ..	Assam	0·601 (at 12·7% m.c.)	673	..	..	..

Properties of Woods—(concld.)

Condition	Static Bending		Impact Bending	Compression parallel to grain	REMARKS
	Modulus of Rupture, kg. per cm.²	Modulus of Elasticity kg./cm.²	Max. height of drop of a 22·68 kg. hammer in cm.	Max. crushing stress kg./cm.²	
9	10	11	12	13	14
Green ..	1030·7	147,400	124	558·7	
Air-dry ..	1235·8	164,700	127	648·0	
Green ..	1020·9	144,100	130	551·1	
Air-dry ..	1233·2	158,400	145	634·4	
Green ..	1000·1	139,900	117	525·4	
Air-dry ..	1203·2	158,700	117	630·5	
Green ..	1034·6	150,200	117	571·7	
Air-dry ..	1284·0	168,500	130	664·8	
Green ..	1038·1	134,400	130	524·1	
Air-dry ..	1248·8	152,800	119	685·5	
Green ..	974·7	145,500	132	495·4	
Air-dry ..	1234·2	163,700	142	603·4	
Green ..	952·6	144,300	114	491·4	
Air-dry ..	1207·0	158,000	127	584·0	
Green ..	870·7	134,100	109	473·9	
Air-dry ..	1094·4	149,500	104	573·7	
Green ..	883·3	128,500	112	478·5	
Air-dry ..	1173·8	154,300	112	623·0	
Green ..	979·9	134,800	124	533·2	
Air-dry ..	1113·8	149,100	99	590·4	
Green ..	998·8	138,900	127	521·5	
Air-dry ..	1406·1	161,500	130	717·6	
Green ..	953·0	132,800	130	482·7	
Air-dry ..	1303·7	157,700	132	631·4	
Green ..	668·2	109,500	99	328·5	Small consignment.
Air-dry ..	957·1	115,400	84	535·7	
Green ..	333·2	57,600	43	165·1	Small consignment.
Air-dry .. (at 12·3% m.c.)	464·4	67,900	48	281·7	
Green ..	945·2	103,600	160	450·9	Small consignment.
Air-dry ..	1204·8	119,200	137	574·3	
Green ..	573·1	109,500	51	300·2	Small consignment.
Air-dry ..	770·8	129,800	71	457·5	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 7·7% m.c.)	758·6	112,300	..	430·4	
Green ..	..	..	..	..	Small consignment.
Air-dry .. (at 12·7% m.c.)	979·9	143,500	94	544·3	

APPENDIX II

CLASSIFICATION OF WOODS ACCORDING TO ANATOMICAL STRUCTURE

(When a character is usually present in a genus or species, the name is printed in roman; less frequent occurrence is indicated by italics).

I. Ring-porous

Berberis
*B. nepalensis
*Camellia
Grewia
Grewia pilosa
*Myricaria
*Pyrenaria
*Tamarix ericoides

II. Vessels extremely large

Bombax
Dipterocarpus
Parashorea stellata
Sterculia

III. Vessels extremely small

Camellia
Eurya
Hydnocarpus alpina
Mansonia gagei

IV. Vessels few to very few

Bombax
Eriodendron
Ochroma
Pentacme
Sterculia
Unona latifolia
Xanthophyllum

V. Vessels very numerous

Balanocarpus
Camellia
Dioticarpus
Eurya
Gordonia
Helicteres
Hydnocarpus alpina
Kayea nervosa
Mansonia gagei
Taraktogenos
Ternstroemia japonica
Vatica lanceaefolia

VI. Vessels in long radial multiples or chains

Asteriastigma
Cadaba
Capparis
Casearia
Flacourtia
Hydnocarpus

* Indicates semi-ring-porous type.

VI. VESSELS IN LONG RADIAL MULTIPLES OR CHAINS—(*contd*).

Maerua
Niebuhria
Scolopia
Taraktogenos
Xylosma

VII. VESSELS IN OBLIQUE CHAINS

Balanocarpus
Calophyllum
Mesua
Poeciloneuron
Shorea farinosa
S. sericeiflora (S. floribunda)
Vateria

VIII. VESSELS IN FLAME-LIKE PATTERNS

Berberis

IX. VESSELS SOLITARY

Anneslea
Calophyllum
Camellia
Cocculus
Dillenia
Eurya
Gordonia
Kayea
Mesua
Ochrocarpus
Poeciloneuron
Pyrenaria
Saurauja
Schima
Xanthophyllum

X. VESSELS IN CLUSTERS

Berberis
Pittosporum
Tamarix dioica

XI. PARENCHYMA IN CONCENTRIC LINES (initial or terminal)

Elaeocarpus
Erinocarpus
Eriodendron
Eriolaena
Grewia
Hopea shingkeng
Magnolia
Manglietia
Michelia
Polygala
Sterculia scaphigera
Talauma

XII. PARENCHYMA DIFFUSE TO DIFFUSE-AGGREGATE

Anisoptera
Anneslea
Cadaba indica
Camellia
Dillenia
Dioticarpus
Dipterocarpus
*Eriodendron
Eurya
Gordonia

* Indicates tendency towards reticulate arrangement.

XII. Parenchyma diffuse to diffuse-aggregate—(*contd.*)

*Grewia
*Heritiera
Hibiscus
Hopea
Ochrocarpus
Parashorea
Pentacme
Pyrenaria
Schima
Shorea robusta
S. talura
S. tumbuggaia
*Sterculia angustifolia
*S. campanulata
*S. foetida
*S. guttata
*S. ornata
*S. urens
*S. villosa
Ternstroemia
*Thespesia
Vateria
Vatica
*Xanthophyllum

XIII. Parenchyma reticulate or nearly so

†Bombax
†Brownlowia
Cadaba trifoliata
†Columbia
†Cullenia
Cyathocalyx
†Durio
Goniothalamus
Grewia microcos
Helicteres
Kydia
†Mansonia dipikae
Miliusa
Mitrephora
†Neesia
Orophea
†Pentace
Polyalthia
†Pterospermum
Saccopetalum
Sageraea
Unona
Xylopia

XIV. Parenchyma in thick apotracheal bands ending abruptly

Calophyllum
Cratoxylon
Garcinia
Kayea
Mesua

XV. Parenchyma vasicentric to aliform

Balanocarpus
‡Calophyllum
Crataeva
Dioticarpus
Dipterocarpus
Erinocarpus
Garcinia
Grewia (excluding G. microcos)
Hibiscus
Hopea
‡Kayea
‡Mesua
‡Ochrocarpus
Parashorea

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* Indicates tendency towards reticulate arrangement.
† Indicates tendency towards diffuse-aggregate arrangement.
‡ Mainly tracheids.

XV. PARENCHYMA VASICENTRIC TO ALIFORM—(*contd.*)

Pentacme
*Poeciloneuron
Shorea
Sterculia campanulata
S. scaphigera
Tamarix
Vateria
Vatica

XVI. PARENCHYMA CONFLUENT

Balanocarpus
Berrya
Erinocarpus
Garcinia
Hopea
Parashorea
Shorea farinosa
S. gratissima
S. tumbuggaia

XVII. PARENCHYMA BANDED

Kayea
Sterculia alata
S. coccinea
S. colorata
S. fulgens
S. populifolia

XVIII. RAYS CONSPICUOUS

Berberis
Cocculus
Goniothalamus
Miliusa roxburghiana
Orophea hexandra
Saurauja
Sterculia angustifolia
S. campanulata
S. guttata
S. ornata
S. villosa
Tamarix
Unona longiflora

XIX. RIPPLE MARKS

Balanocarpus
Berrya
Bombax
Brownlowia
Columbia
Eriodendron
Eriolaena
Grewia
Heritiera
Hibiscus
Hopea glabra
Kydia
Mansonia
Pentace
Pterospermum
Sterculia
Thespesia

XX. LONGITUDINAL GUM CANALS – SCATTERED

Anisoptera
Dipterocarpus
Vateria
Vatica

* Mainly tracheids.

XXI. Longitudinal gum canals – concentric

Balanocarpus
Capparis
Dioticarpus
Heritiera
Hibiscus
Hopea
Parashorea
Pentacme
Shorea
Sterculia
Vatica

XXII. Radial gum canals

Garcinia cowa
Ochrocarpus

XXIII. Included phloem

Cadaba trifoliata
Cocculus
Maerua
Niebuhria

XXIV. Wood light to very light

Bombax
Echinocarpus
Eriodendron
Kydia
Neesia
Ochroma
Saurauja
Sterculia (excluding S. alata, S. foetida and S. urens)
Unona latifolia

XXV. Wood very heavy

Balanocarpus
Berrya
Dioticarpus
Heritiera
Homalium
Hopea glabra
H. shingkeng
H. wightiana
Mesua
Ochrocarpus
Poeciloneuron
Shorea obtusa
S. tumbuggaia
Scolopia

APPENDIX III

CLASSIFICATION OF WOODS ACCORDING TO USES

AGRICULTURAL IMPLEMENTS
(Ploughs, yokes, harrows, etc.)

Berrya ammonilla
Cratoxylon neriifolium
Erinocarpus nimmonii
Eriolaena candollei
Flacourtia spp.
Grewia spp.
Heritiera spp.
Homalium spp.
Hopea odorata
Miliusa spp.
Pentacme suavis
Pterospermum spp.
Schima wallichii
Shorea obtusa
S. robusta
S. talura
Thespesia populnea

BATTERY SEPARATORS

Michelia spp.

BEAMS AND SCANTLINGS

See under House building

BEARINGS

Heritiera spp.
Hopea parviflora
Mesua ferrea

BOAT BUILDING

(*a*) *Dugouts*

Anisoptera scaphula
Bombax spp.
Dillenia spp.
Dipterocarpus spp.
Eriodendron anfractuosum
Hopea odorata
Pentacme suavis
Shorea robusta
Sterculia spp.

(*b*) *Hull*

Anisoptera scaphula
Berrya ammonilla
Calophyllum spp.
Heritiera spp.
Hopea spp.
Pterospermum spp.
Pentace burmanica
Sageraea elliptica
Thespesia populnea

(c) *Masts*

Calophyllum spp.
Dipterocarpus spp.
Heritiera spp.
Homalium spp.
Pentace burmanica
Sageraea elliptica

(d) *Oars*

Calophyllum spp.
Dillenia spp.
Dipterocarpus spp.
Grewia spp.
Heritiera spp.
Miliusa spp.
Saccopetalum tomentosum
Thespesia populnea
Vateria indica

BOBBINS AND SHUTTLES

Grewia tiliaefolia
Michelia spp.
Saccopetalum spp.
Vatica spp.

BRIDGES

Calophyllum spp.
Dipterocarpus spp.
Garcinia speciosa
Heritiera spp.
Hopea spp.
Mesua ferrea
Parashorea stellata
Pentacme suavis
Shorea spp.

BUOYS AND FLOATS

Eriodendron anfractuosum
Ochroma lagopus
Sterculia ornata

CARTS

(a) *Axle and hubs*

Heritiera spp.
Hopea parviflora
Mesua ferrea
Miliusa spp.
Pentacme suavis
Shorea obtusa
S. robusta
S. talura

(b) *Felloes and wheels*

Berrya ammonilla
Capparis aphylla
Cyathocalyx martabanicus
Dipterocarpus spp.
Grewia tiliaefolia
Hopea odorata
Mitrephora spp.
Thespesia populnea

(c) *Shafts*

Balanocarpus utilis
Berrya ammonilla
Dipterocarpus tuberculatus
Grewia tiliaefolia
Heritiera spp.
Homalium spp.
Hopea parviflora
Mesua ferrea
Miliusa velutina
Pentacme suavis
Sageraea spp.
Shorea spp.
Thespesia populnea

(d) *Spokes*

Berrya ammonilla
Eriolaena candollei
Grewia tiliaefolia
Heritiera spp.
Hopea odorata
Miliusa spp.
Mitrephora spp.
Shorea robusta
Thespesia populnea

COOPERAGE

(a) *Dry*

Bombax spp.
Grewia spp.
Michelia champaca
Saccopetalum tomentosum
Shorea robusta
Sterculia urens

(b) *Wet*

Berrya ammonilla
Grewia spp.
Shorea robusta

FURNITURE AND CABINET MAKING

Berrya ammonilla (bentwood)
Calophyllum spp.
Cullenia excelsa
Elaeocarpus spp.
Grewia tiliaefolia (bentwood)
Manglietia spp.
Mansonia dipikae
Michelia spp.
Miliusa velutina
Pentace burmanica
Pterospermum spp.
Saccopetalum tomentosum (bentwood)
Sageraea elliptica (bentwood)
Shorea assamica
Talauma spp.
Thespesia populnea
Xylopia parvifolia

HOUSE BUILDING

(a) *Ceiling*

Anisoptera oblonga
A. scaphula
Calophyllum spp.
Dipterocarpus spp.
Echinocarpus spp.
Gynocardia odorata

HOUSE BUILDING—(*contd.*)

(*a*) *Ceiling*—(contd.)

Magnolia spp.
Michelia spp.
Shorea assamica
Talauma spp.
Vateria indica

(*b*) *Flooring*

Balanocarpus utilis
Calophyllum spp.
Dipterocarpus spp.
Hopea spp.
Miliusa spp.
Shorea spp. (except S. assamica)

(*c*) *Posts*

Balanocarpus utilis
Calophyllum spp.
Eurya spp.
Flacourtia spp.
Gynocardia odorata
Heritiera spp.
Hibiscus macrophyllus
Mesua ferrea
Pentacme suavis
Poeciloneuron indicum
Shorea spp.
Vatica spp.
Xylosma longifolium

(*d*) *Rafters*

Balanocarpus utilis
Calophyllum spp.
Erinocarpus nimmonii
Hibiscus macrophyllus
Kayea spp.
Shorea spp.

(*e*) *General*

Asteriastigma macrocarpa
Berrya ammonilla
Brownlowia elata
Capparis spp.
Casearia spp.
Cratoxylon neriifolium
Dillenia spp.
Eriolaena spp.
Garcinia spp.
Gordonia obtusa
Grewia spp.
Hydnocarpus alpina
Kydia calycina
Mansonia dipikae
Ochrocarpus longifolius
O. siamensis
Parashorea stellata
Pterospermum spp.
Schima wallichii
Sterculia foetida
S. urens
Ternstroemia japonica
T. penangiana
Vatica spp.
Xanthophyllum spp.

MARINE PILES AND HARBOUR WORK

Heritiera spp.
Hopea spp.
Mesua ferrea
Pentacme suavis
Shorea spp.
S. robusta (fenders for docks)

MATCHES

Bombax insigne
B. malabaricum
Echinocarpus dasycarpus
Elaeocarpus lanceaefolius
E. tuberculatus
Hydnocarpus wightiana
Kydia calycina
Michelia spp.
Polyalthia spp.
Sterculia alata
S. campanulata
Taraktogenos kurzii
Vateria indica

MATHEMATICAL INSTRUMENTS

Berberis spp.
Eurya spp.
Gordonia obtusa
Helicteres isora
Hydnocarpus alpina
Magnolia campbellii
Mansonia dipikae
Pentace burmanica
Pittosporum spp.
Polygala arillata
Xylopia parvifolia

MINE WORK AND PIT PROPS

Dipterocarpus indicus
Heritiera spp.
Hopea parviflora
Mesua ferrea
Shorea robusta
S. talura
S. tumbuggaia

MOTOR LORRY AND BUS BODIES

Calophyllum spp.
Dillenia indica
D. pentagyna
Dipterocarpus spp.
Grewia tiliaefolia (for bent parts)
Sageraea spp. (for bent parts)
Xanthophyllum flavescens

PACKING CASES

(*a*) *Light*

Anisoptera oblonga
A. scaphula
Bombax insigne
B. malabaricum
Columbia floribunda
Cullenia excelsa
Grewia laevigata
Kydia calycina
Sterculia alata
S. campanulata
S. villosa
Vateria indica

(*b*) *Heavy*

Calophyllum spp.
Dillenia spp.
Dipterocarpus macrocarpus
Dipterocarpus spp.
Michelia spp.
Miliusa spp.
Polyalthia spp.
Pterospermum spp.
Shorea assamica
Talauma spp.

PENCILS

Bombax malabaricum
Cullenia excelsa
Elaeocarpus tuberculatus
Kydia calycina
Michelia champaca
M. excelsa
Schima wallichii

PEN-HOLDERS

Asteriastigma macrocarpa
Berberis spp.
Bombax insigne
B. malabaricum
Cascaria spp.
Camellia spp.
Eurya spp.
Gordonia obtusa
Helicteres isora
Hydnocarpus spp.
Pittosporum spp.
Xylosma longifolium

PICKER ARMS

Grewia tiliaefolia
Heritiera spp.
Hopea parviflora
Saccopetalum tomentosum
Sageraea elliptica
Shorea robusta

POLES

Calophyllum tomentosum
C. wightianum
Cullenia excelsa
Dipterocarpus spp.
Heritiera minor
Homalium tomentosum
Mesua ferrea
Poeciloneuron indicum
Shorea assamica
S. robusta
Vatica lanceaefolia

RAILWAY SLEEPERS

(*a*) *Treated* (with or without incision)

Cullenia excelsa
Dillenia spp.
Dipterocarpus spp.
Hopea spp.
Kayea assamica
Magnolia campbellii
M. pterocarpa
Poeciloneuron indicum
Polyalthia simiarum
P. pterospermum
Shorea assamica
Vatica lanceaefolia

(*b*) *Untreated* (all heart)

Hopea odorata
Mesua ferrea
Pentacme suavis
Shorea robusta

RAILWAY CARRIAGE AND WAGON BUILDING

Berrya ammonilla
Calophyllum spp.
Dipterocarpus spp.
Hopea odorata
Michelia spp.
Pentace burmanica
Shorea robusta

RICE POUNDER

Eriolaena candollei
Hopea spp.
Poeciloneuron indicum
Shorea robusta
S. tumbuggaia

SHIP BUILDING

Dipterocarpus spp. (stage plank)
Shorea robusta (shifting board for grain loading, keel blocks, shores, etc.)

SPORTING REQUISITES

(*a*) *Billiard cue*

Grewia tiliaefolia
Polyalthia fragrans
Saccopetalum tomentosum
Sageraea elliptica

(*b*) *Cricket stumps*

Grewia tiliaefolia
Polyalthia fragrans

(*c*) *Fishing rods*

Sageraea elliptica

(*d*) *Golf clubs*

Grewia elastica (shafts)
G. tiliaefolia (shafts)
Mesua ferrea (heads)
Sageraea elliptica (shafts)

(*e*) *Gun stocks*

Mansonia dipikae
Miliusa velutina
Thespesia populnea

TENT POLES

Calophyllum spp.
Grewia tiliaefolia
Heritiera spp.
Shorea robusta

Tool handles and helves

Berberis spp. (for kukri handles)
Berrya ammonilla
Capparis spp. (for small tools)
Camellia spp. (for small tools)
Cyathocalyx martabanicus
Grewia elastica
G. oppositifolia
G. tiliaefolia
Heritiera spp.
Kayea floribunda
Miliusa velutina
Mitrephora maingayi
Sageraea elliptica
Shorea robusta (for axes)
S. talura (for axes)
Thespesia populnea

Toys and carved articles

Anneslea fragrans
Berberis spp.
Bombax insigne
B. malabaricum
Cadaba indica
Camellia spp.
Casearia spp.
Crataeva religiosa
Eriodendron anfractuosum
Gordonia obtusa
Helicteres isora
Hibiscus macrophyllus
H. tiliaceous
Hydnocarpus alpina
Ochroma lagopus
Magnolia spp.
Manglietia spp.
Michelia spp.
Myricaria germanica
Pittosporum spp.
Polyalthia spp.
Polygala arillata
Pyrenaria camelliaeflora
P. serrata
Tamarix spp.

Veneers and plywood

Bombax insigne
B. malabaricum
Calophyllum spp.
Cullenia excelsa
Dillenia spp.
Dipterocarpus indicus
D. macrocarpus
Kydia calycina
Magnolia spp.
Manglietia spp.
Michelia spp.
Polyalthia spp.
Pterospermum acerifolium
Schima wallichii
Shorea assamica
Sterculia spp.
Talauma spp.
Vateria indica
Xylopia parvifolia

APPENDIX IV

LATEST CHANGES IN NOMENCLATURE OF THE SPECIES DEALT WITH IN THE BOOK

Names given in the book	*Latest names given by the Forest Botanist*
DILLENIACEAE	
Delima sarmentosa L.	Tetracera asiatica (Lour.) Hoogl.
Dillenia pulcherrima Kurz	D. aurea Sm.
MAGNOLIACEAE	
Michelia cathcartii Hk. f. & Th.	Alcimandra cathcartii (Hk. f. & Th.) Dandy
M. excelsa Blume	M. doltsopa Buch. Ham. ex DC.
Talauma phellocarpa King	Michelia baillonii Finet & Gagnep.
ANNONACEAE	
Miliusa tectona Hutchinson ex C. E. Parkinson	Saccopetalum tectonum (Hutchinson ex Parkinson) Chatterjee
Polyalthia andamanica Kurz	P. jenkensii (Hk. f. & Th.) Hk. f. & Th.
P. cerasoides Benth & Hk. f.	P. cerasoides (Roxb.) Bedd.
P. fragrans Benth & Hk. f.	P. fragrans (Dalz.) Bedd.
P. longifolia Benth & Hk. f.	P. longifolia (Sonnerat) Thw.
P. simiarum Benth & Hk. f.	P. simiarum (Hk. f. & Th.) Hk. f. & Th.
P. suberosa Benth. & Hk. f.	P. suberosa (Roxb.) Thw.
Saccopetalum tomentosum Hk. f. & Th.	Miliusa tomentosa (Roxb.) J. Sinclair
S. unguiculatum C. E. C. Fischer	Miliusa ungiculata (C. E. C. Fischer) J. Sinclair
Sageraea laurina Dalzell	S. laurifolia (Grah.) Blatter
Unona latifolia Hk. f. & Th.	Cananga latifolia (Hk. f. & Th.) Finet & Gagnep.
U. longiflora Roxb.	Desmos longiflorus (Roxb.) Saff.
BERBERIDACEAE	
Berberis coriaria Royle	B. aristata DC.
B. nepalensis Spreng.	Mahonia nepaulensis DC.

CAPPARIDEAE

Cadaba indica Lamk.	C. farinosa Forsk.
Capparis aphylla Roth	C. decidua Pax
Capparis divaricata Lamk.	C. stylosa DC.
C. horrida L. f.	C. zeylanica L.
Crataeva religiosa Forst.	This name refers to a Polynesian species which is distinct from the Indian species. There are two different plants in India which may be considered as distinct species. They are :—C. nurvala Buch.-Ham. and C. odora Buch.-Ham.
Niebuhria linearis DC.	N. apetala Dunn

FLACOURTIACEAE

Asteriastigma macrocarpa Bedd.	Hydnocarpus macrocarpus (Bedd.) Warb.
Flacourtia cataphracta Roxb.	F. jangomas (Lour.) Raeusch.
F. ramontchi L' Heritier	F. indica (Burm. f.) Merr. (in part)
Hydnocarpus wightiana Blume	H. laurifolia (Denn.) Sleum.
Scolopia rhinanthera Clos.	S. macrophylla (W. & A.) Clos.
Taraktogenos kurzii King	Hydnocarpus kurzii (King) Warb.

TAMARICACEAE

Tamarix articulata Vahl	T. aphylla Lanza

GUTTIFERAE

Calophyllum spectabile Willd.	C. soulattri Burm. f.
C. wightianum Wall.	C. apetalum Willd.
Ochrocarpus longifolius Benth. & Hk. f.	Mammea longifolia Pl. & Tr.
O. siamensis T. And.	Mammea siamensis T. Anders.

THEACEAE

Camellia drupifera Lour.	C. kissi Wall.
C. thea Link.	C. sinensis (L.) O. Ktze.
Eurya symplocina Blume	E. cerasifolia (D. Don) Kobuski
Schima wallichii Choisy	S. wallichii (DC.) Korth.
Ternstroemia japonica Thunb.	T. gymnanthera (W. & A.) Sprague
T. penangiana Choisy.	T. wallichiana Engler

MALVACEAE

Thespesia populnea Correa.	T. populnea (L.) Sol.

BOMBACACEAE

Bombax insigne Wall.	Salmalia insignis (Wall.) Schott & Endl.
B. malabaricum DC.	Salmalia malabarica (DC.) Schott & Endl.
Durio zibethinus L.	D. zibethinus Murr.
Eriodendron anfractuosum DC.	Ceiba pentandra (L.) Gaertn.
Ochroma lagopus Sw.	Ochroma pyramidale (Cav.) Urban

STERCULIACEAE

Pterospermum glabrescens Wight & Arn.	P. diversifolium Bl.
Sterculia alata Roxb.	Pterygota alata (Roxb.) R. Br.
S. campanulata Wall.	Pterocymbium tinctorium (Blanco) Merr.
S. colorata Roxb.	Firmiana colorata (Roxb.) R. Br.
S. fulgens Wall.	Erythropsis fulgens (Wall. ex Mast.) Ridley
S. scaphigera Wall.	Scaphium wallichii Schott & Endl.

TILIACEAE

Berrya ammonilla Roxb.	B. cordifolia (Willd.) Burret
Columbia floribunda Wall.	Colona floribunda (Kurz) Craib
Grewia laevigata Vahl.	G. glabra Blume
G. microcos L.	Microcos paniculata L.
G. oppositifolia Roxb.	G. optiva J. R. Drumm.
G. pilosa Lam.	G. flavescens Juss.
G. populifolia Vahl.	G. tenax (Forsk.) Aschers. & Schwf.
G. salvifolia Heyne	G. damine Gaertn.

ELAEOCARPACEAE

Echinocarpus assamicus Benth.	Sloanea assamica Rehd. & Wib.
E. dasycarpus Benth.	Sloanea dasycarpa (Bth.) Hemsl.
Elaeocarpus ferrugineus Bedd.	E. recurvatus Corner
E. ganitrus Roxb.	E. sphaericus (Gaertn.) K. Schum.
E. robustus Roxb.	E. tectorius (Lour.) Poir.

INDEX I.

SCIENTIFIC NAMES

The references in heavy type are to the detailed accounts of the various species.

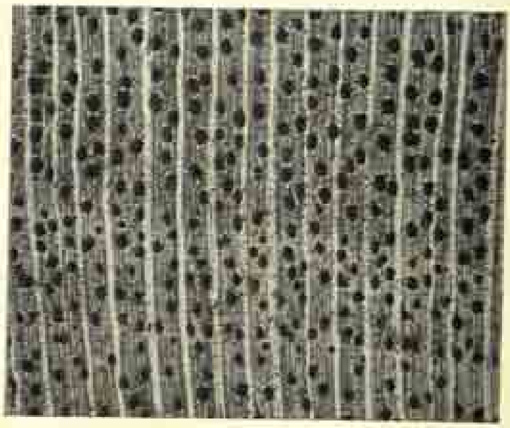
INDEX II

TRADE AND COMMON NAMES

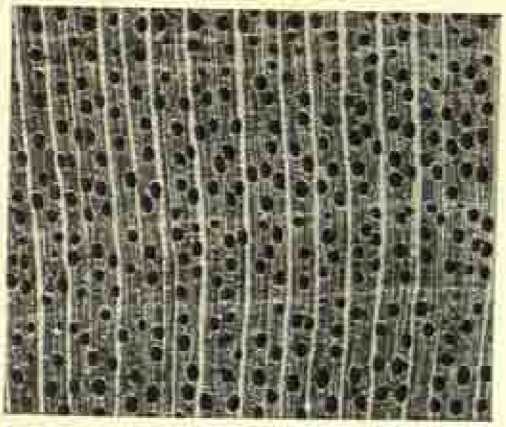
N.C.—P.Z.O.—J.S. 893—14-12-56—1,000 bks.

PLATES

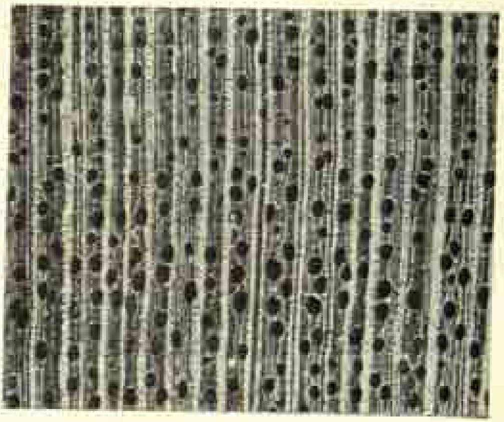
1. Dillenia aurea Smith



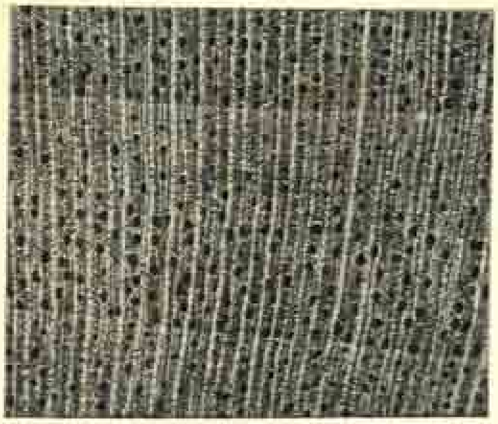
2. Dillenia indica L.



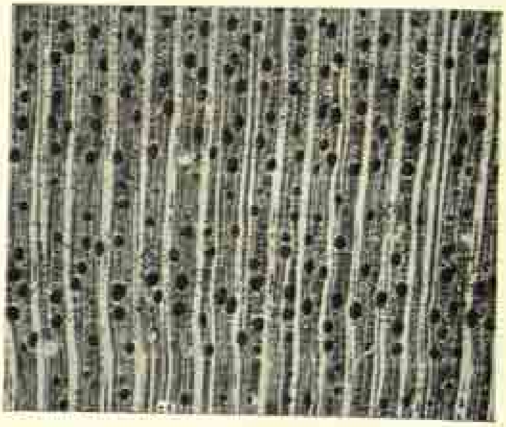
3. Dillenia parviflora Griff.



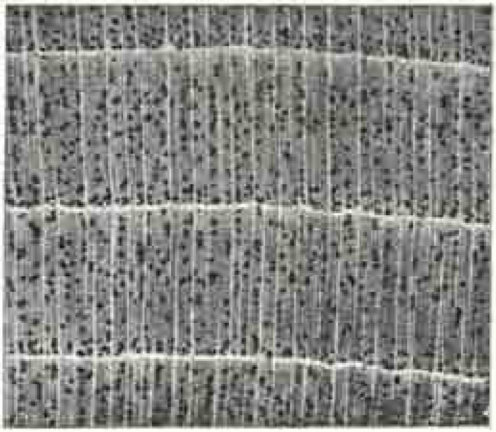
4. Dillenia pentagyna Roxb.



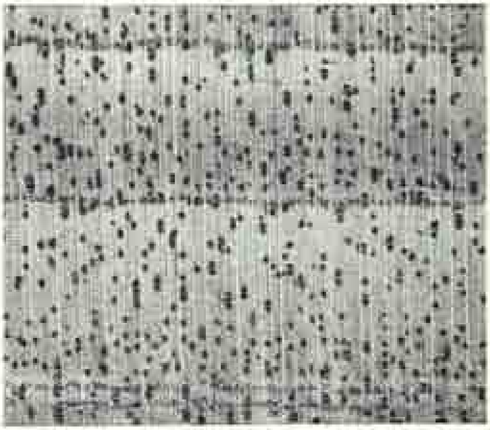
5. Dillenia pulcherrima Kurz (D. aurea Smith)



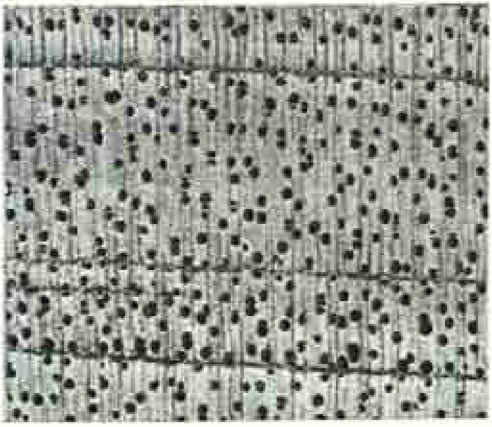
6. Dillenia scabrella (D. Don) Roxb. ex Wall.



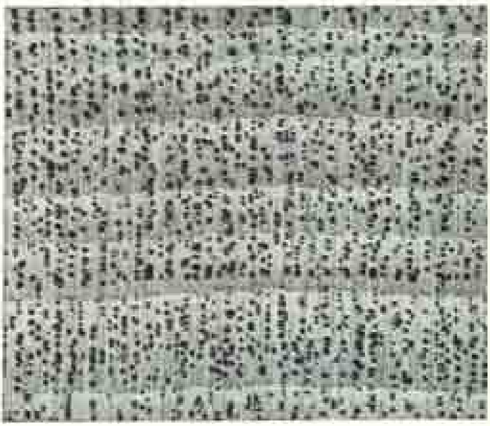
7. Magnolia campbellii Hk. f. & Th.



8. Manglietia hookeri Cubitt & W. W. Smith

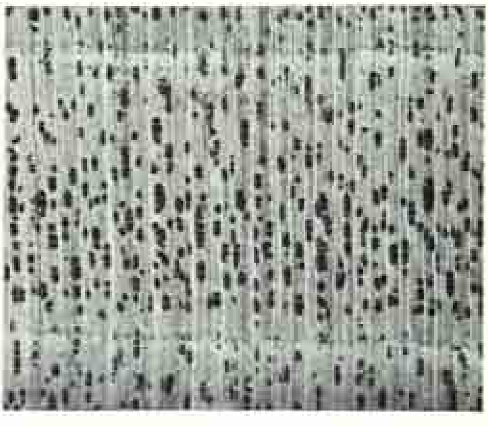


9. Michelia champaca L.

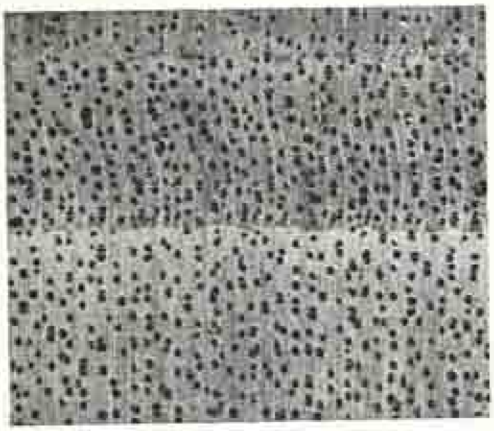


10. Michelia excelsa Bl. ex Wall.
(M. doltsopa Buck-Ham. ex DC.)

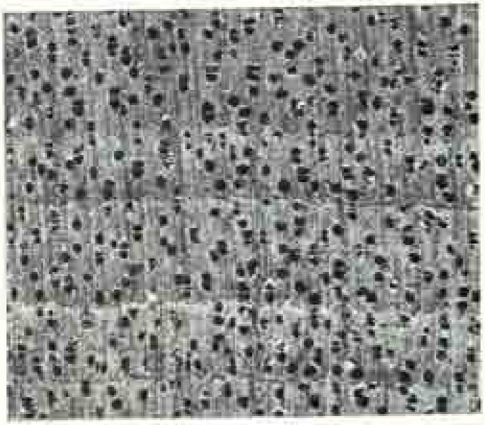
11. Michelia lanuginosa Wall.



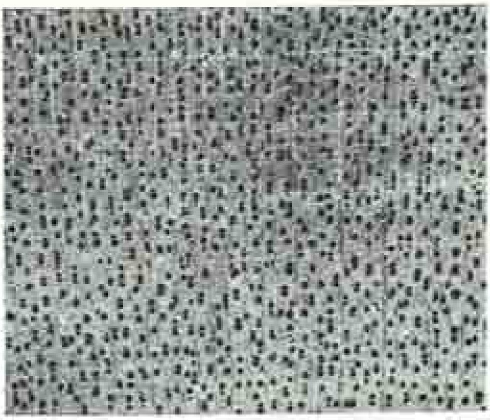
12. Michelia nilagirica Zenk.



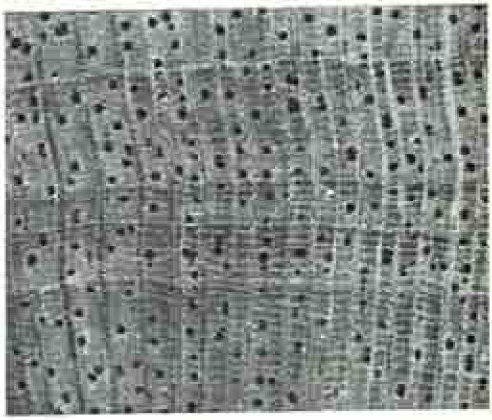
13. Michelia oblonga Wall.



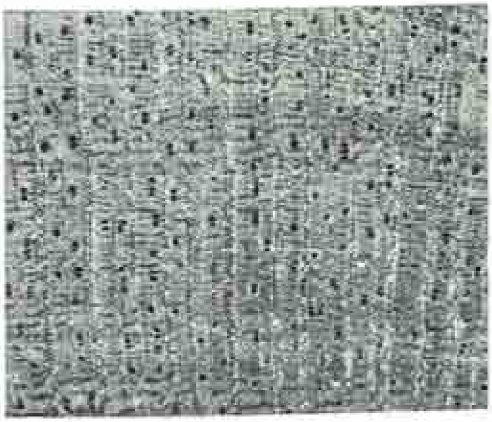
14. Talauma phellocarpa King
(Michelia baillonii Finet & Gagnep.)



15. Alphonsea ventricosa (Roxb.) Hk. f. & Th.

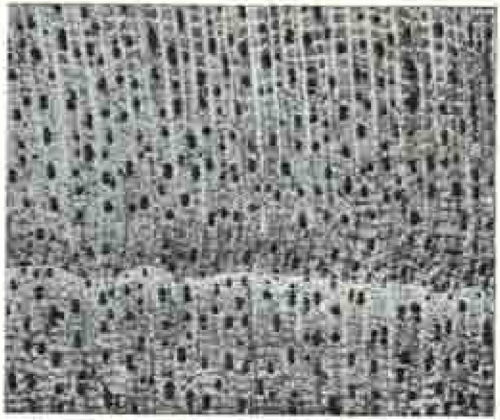


16. Cyathocalyx martabanicus Hk. f. & Th.

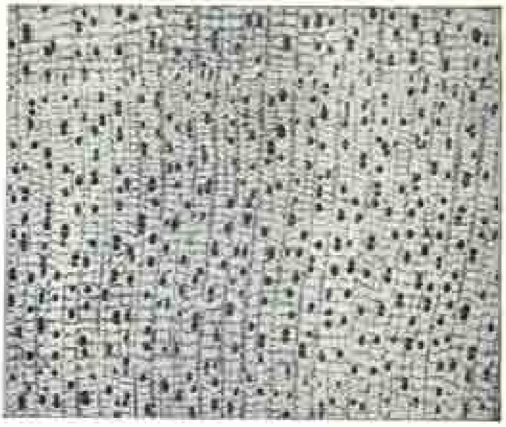


17. Goniothalamus griffithii Hk. f. & Th.

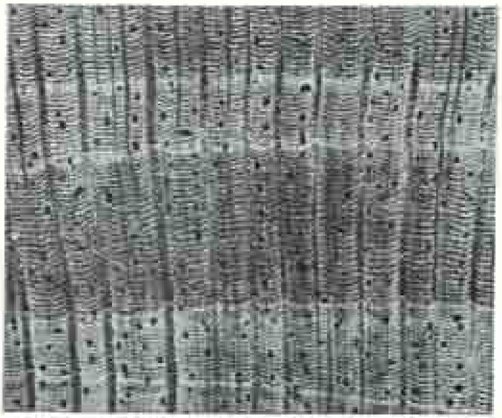
18. Miliusa roxburghiana (Wall.) Hk. f. & Th.



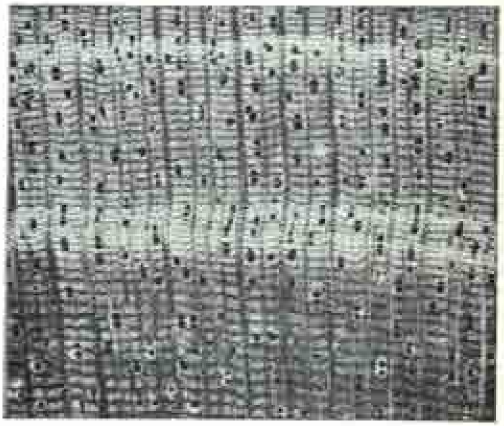
19. Miliusa velutina (Dunal) Hk. f. & Th.



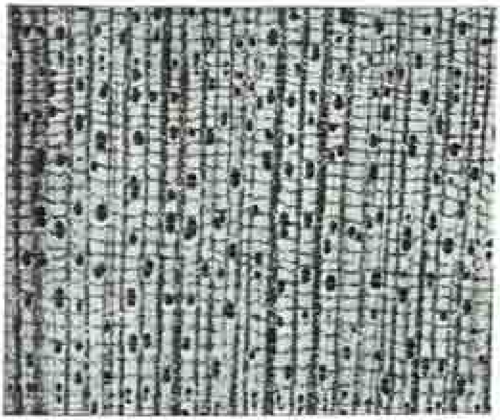
20. Mitrephora maingayi Hk. f. & Th.



21. Orophea hexandra Blume

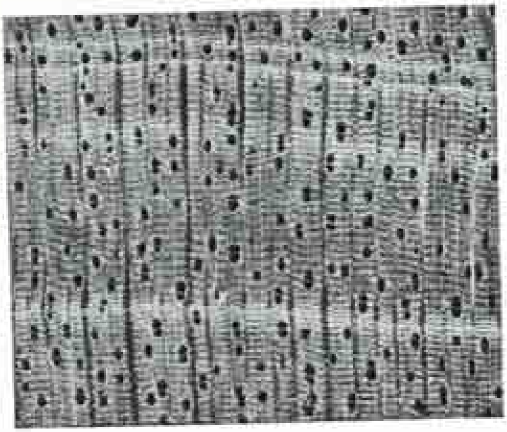


22. Polyalthia andamanica Kurz
(Polyalthia jenkensii (Hk. f. & Th.) Hk. f. & Th.)

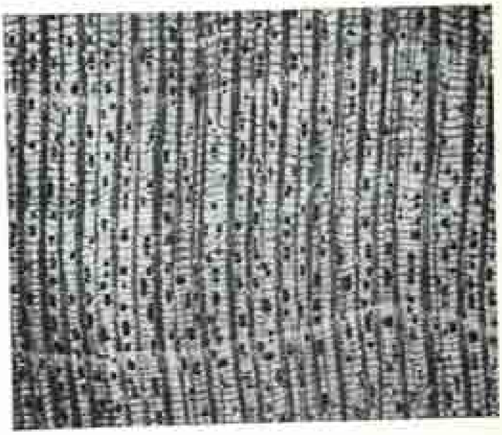


23. Polyalthia cerasoides (Roxb.) Bedd.

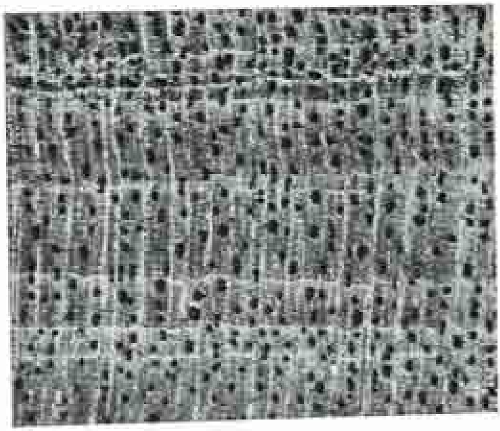
24. Polyalthia fragrans (Dalz.) Bedd.



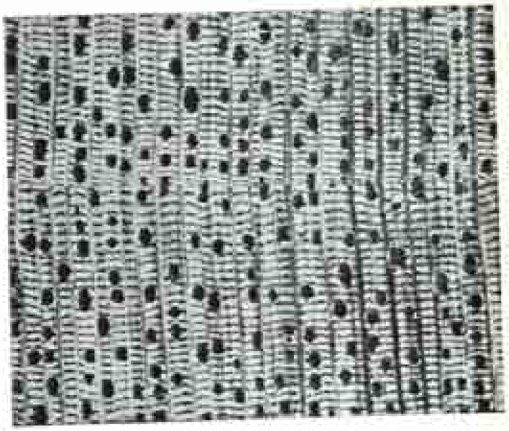
25. Polyalthia fragrans (Dalz.) Bedd.



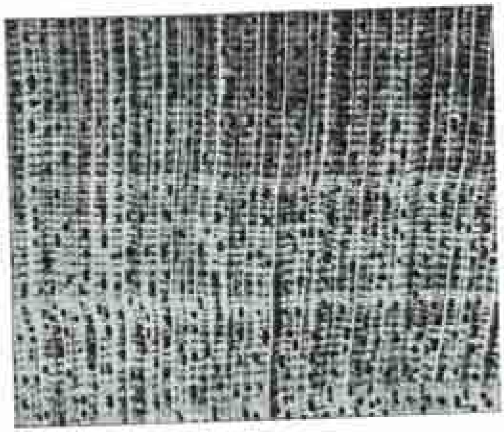
26. Saccopetalum tomentosum Hk. f. & Th.
(Miliusa tomentosa (Roxb.) J. Sinclair)



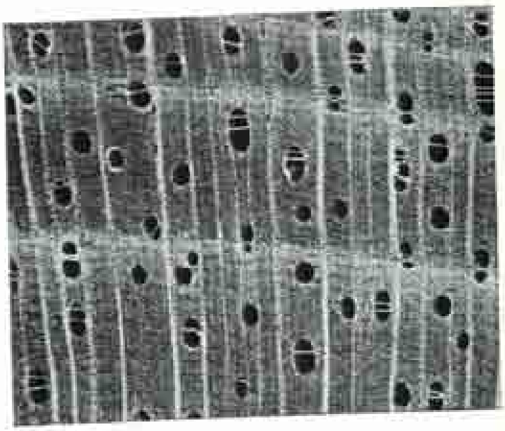
27. Sageraea elliptica (A. DC.) Hk. f. & Th.



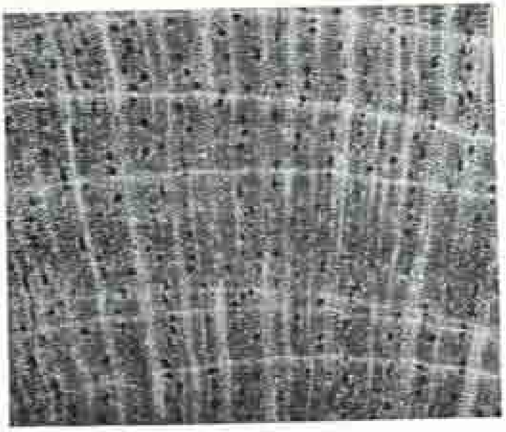
28. Sageraea laurina Dalz.
(Sageraea laurifolia (Grah.) Blatter)



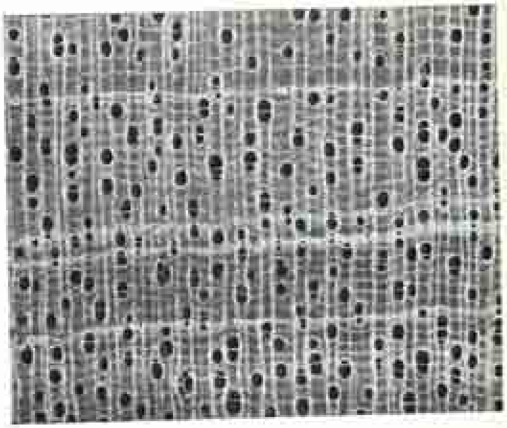
29. Sageraea listeri King



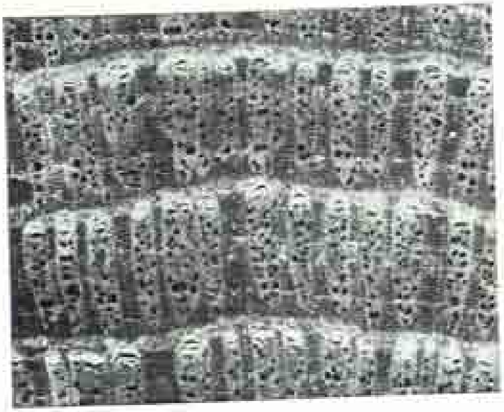
30. Unona latifolia Hk. f. & Th.
(Canaga latifolia (Hk. f. & Th.) Finet & Gagnep.)



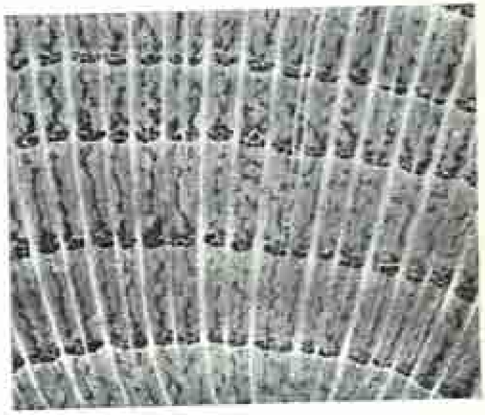
31. Unona longiflora Roxb.
(Desmos longiflorus (Roxb.) Saff.)



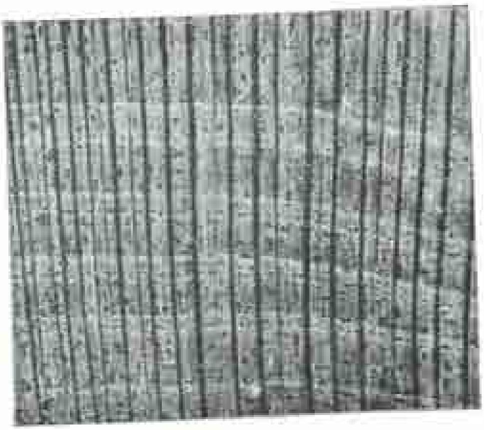
32. Xylopia parvifolia Hk. f. & Th.



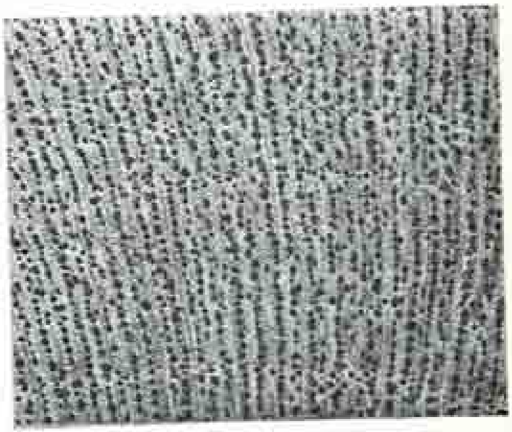
33. Cocculas laurifolius DC.



34. Berberis aristata DC.

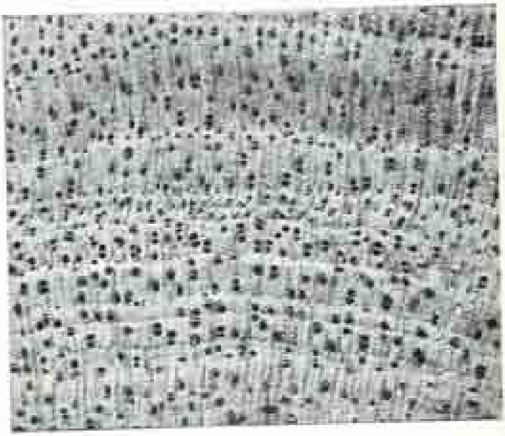


35. Berberis nepalensis Spr.
(Mahonia nepaulensis DC.)

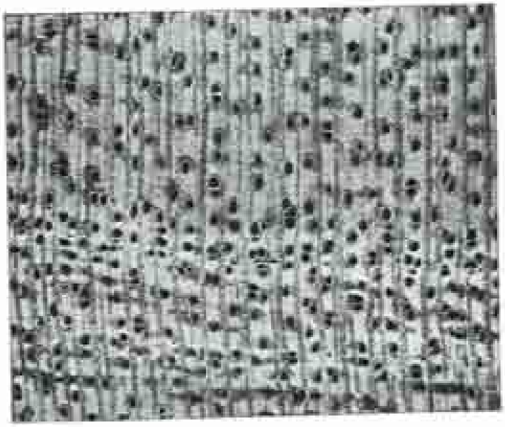


36. Cadaba indica Lamk. (Cadaba farinosa Forsk.)

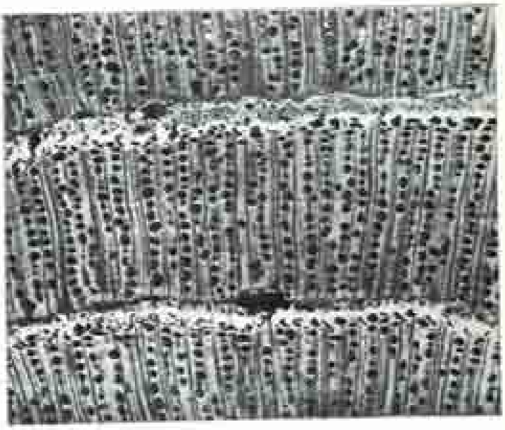
37. Cadaba trifoliata (Roxb.) W. & A.



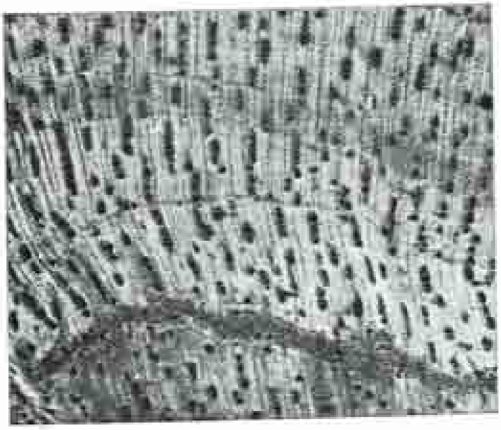
38. Capparis aphylla Roth. (Capparis decidua Pax)



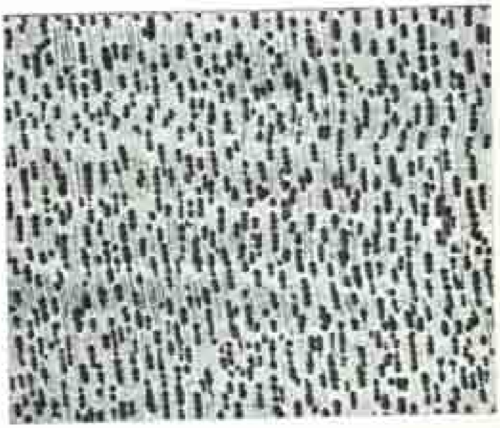
39. Crataeva religiosa Forst.
(Crataeva nurvala Buch-Ham. in part)



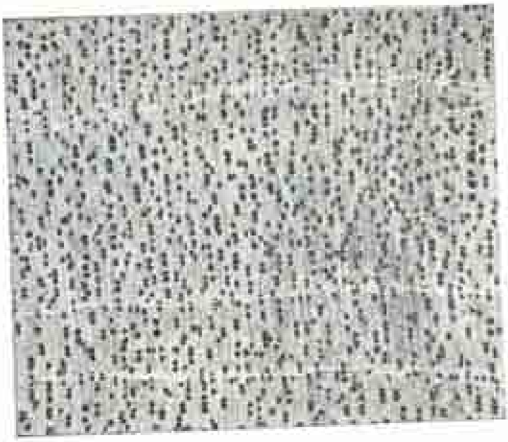
40. Maerua arenaria Hk. f. & Th.



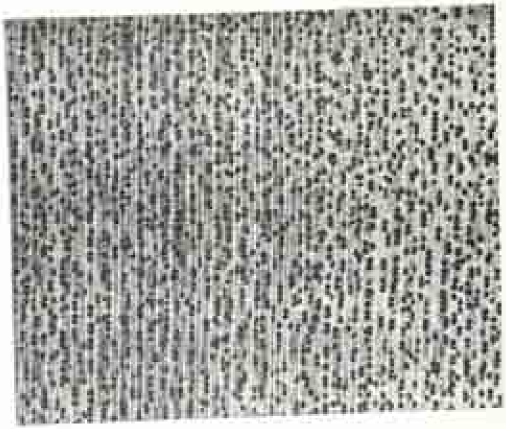
41. Niebuhria linearis DC.
(Niebuhria apetala Dunn)



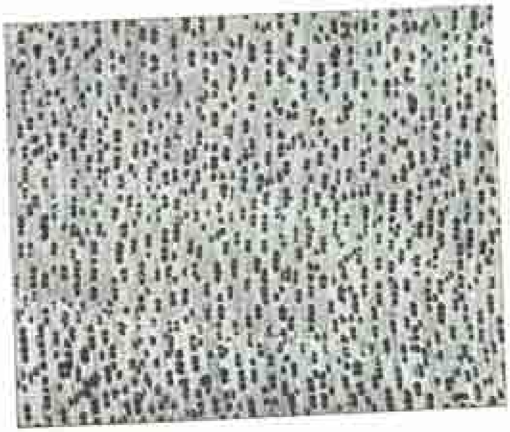
42. Flacourtia cataphracta Roxb. ex Willd.
(Flacourtia jangomas (Lour.) Raeusch.)



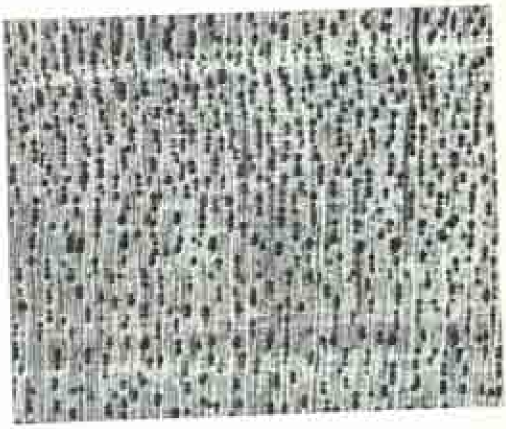
43. Gynocardia odorata R. Br.



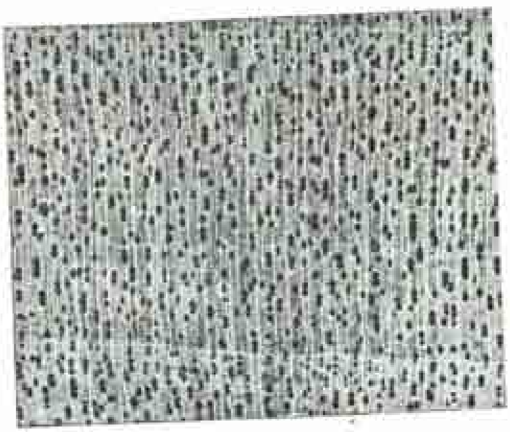
44. Hydnocarpus alpina Wt.



45. Hydnocarpus wightiana Bl.
(Hydnocarpus laurifolia (Denn.) Sleum.)

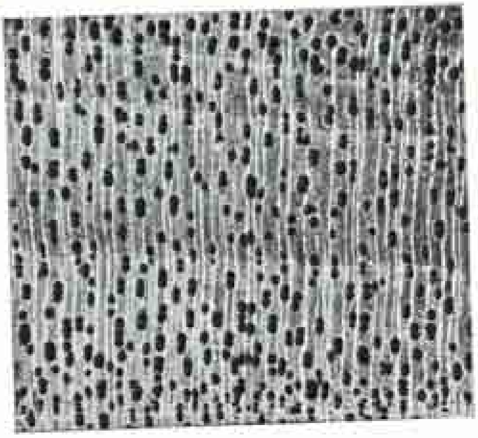


46. Scolopia rhinanthera Clos.
(Scolopia macrophylla (W. & A.) Clos.)

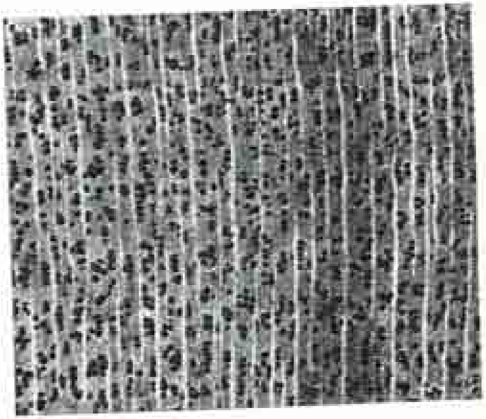


47. Xylosma longifolium Clos.

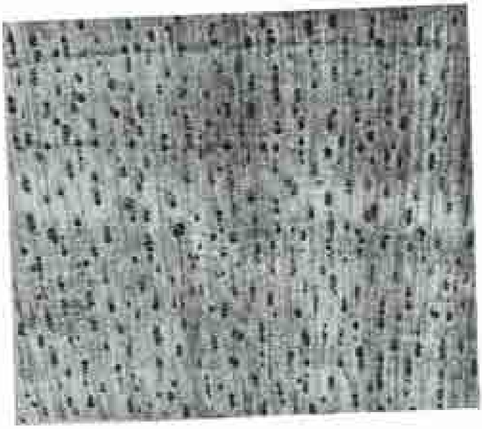
48. Casearia tomentosa Roxb.



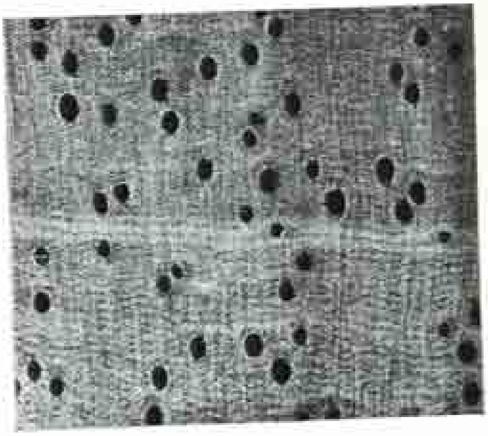
49. Homalium zeylanicum Benth.



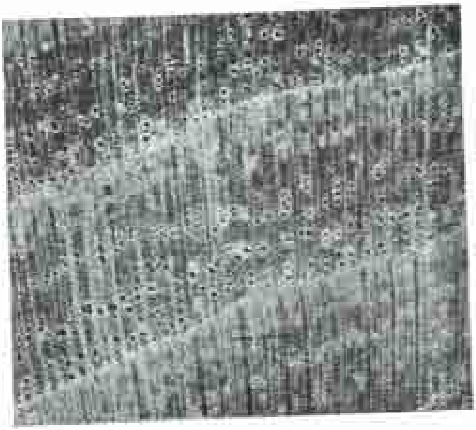
50. Pittosporum floribundum W. & A.



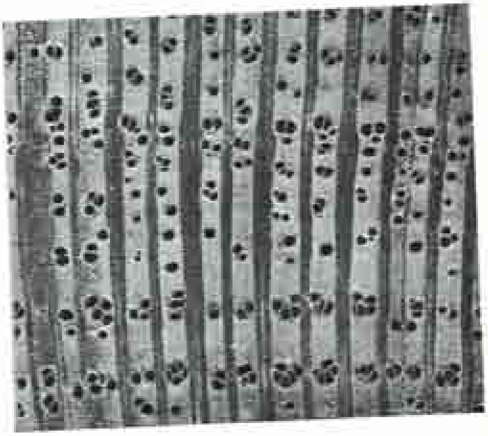
51. Polygala arillata Ham.



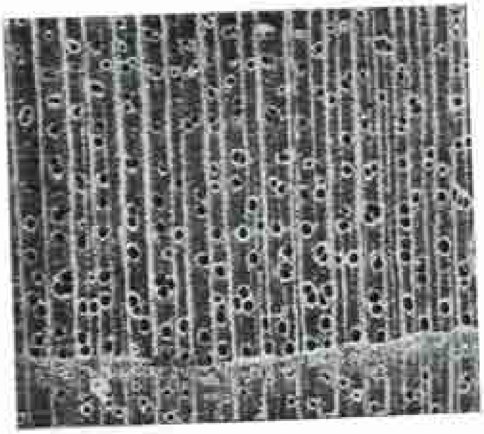
52. Xanthophyllum flavescens Roxb.



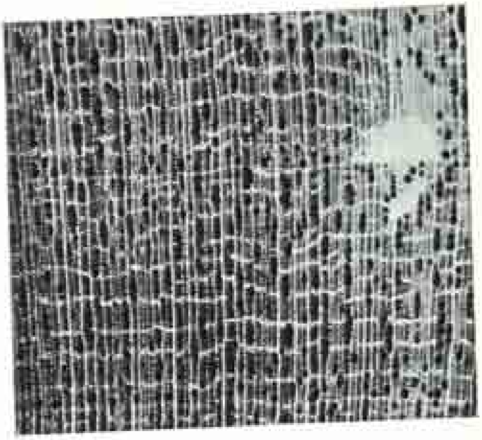
53. Myricaria germanica Desv.



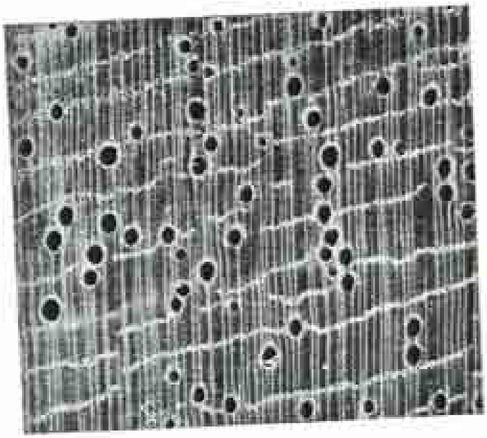
54. Tamarix articulata Vahl



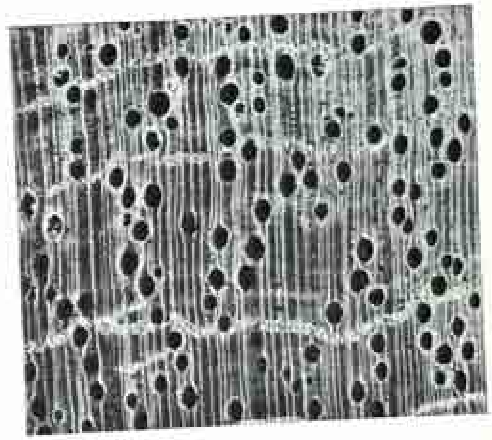
55. Tamarix dioica Roxb.



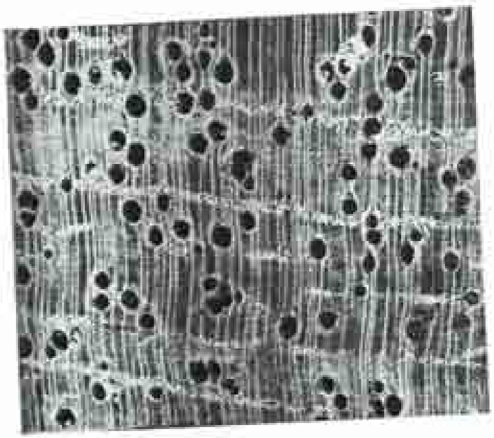
56. Cratoxylon neriifolium Kurz



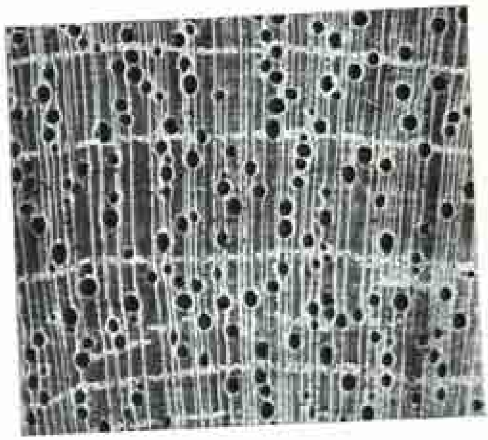
57. Calophyllum inophyllum L.



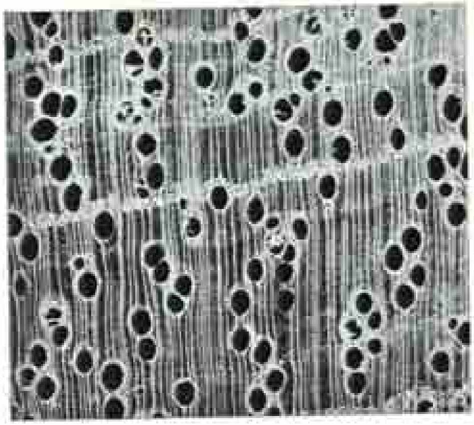
58. Calophyllum kunstleri King



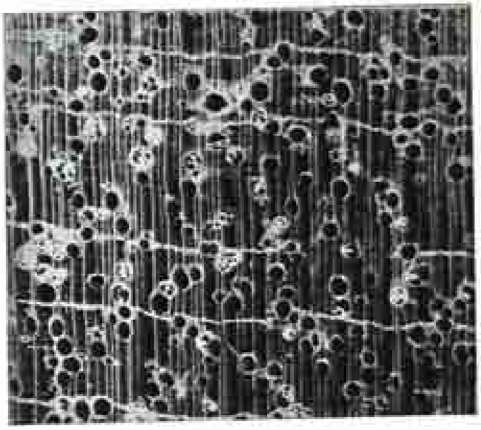
59. Calophyllum polyanthum Wall.



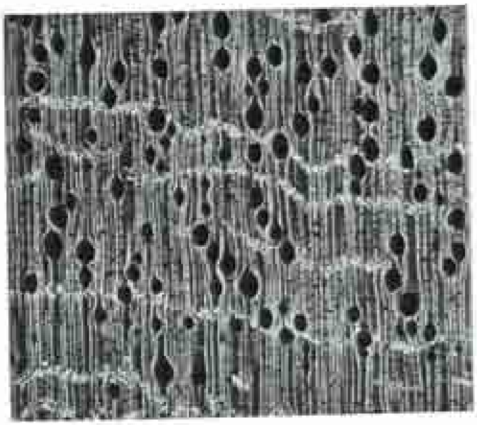
60. Calophyllum spectabile Willd.



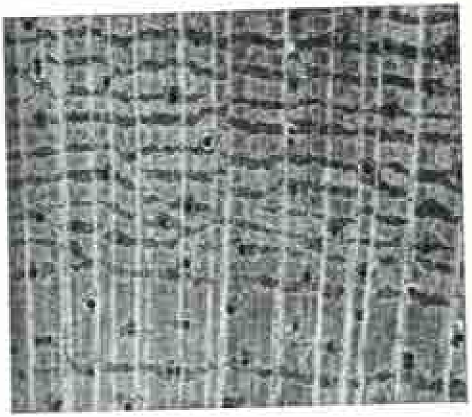
61. Calophyllum tomentosum Wight



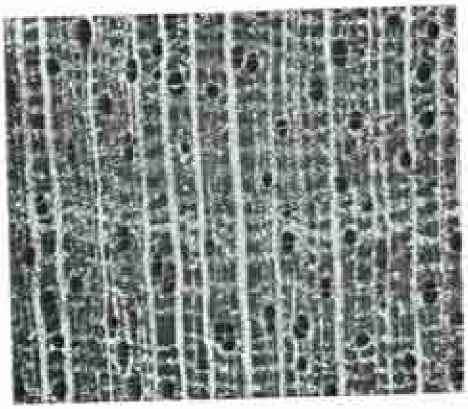
62. Calophyllum venustum King



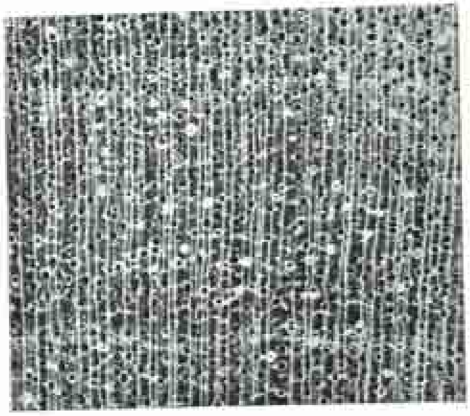
63. Calophyllum wightianum Wall.



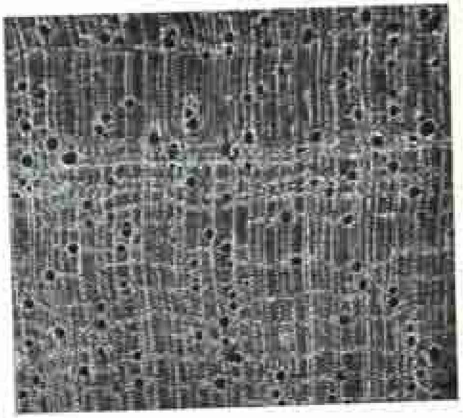
64. Garcinia cowa Roxb.



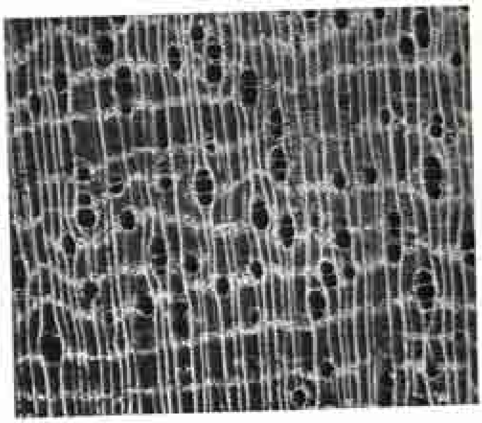
65. Garcinia indica Choisy



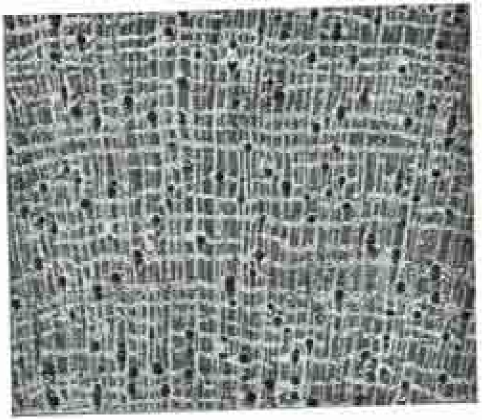
66. Garcinia speciosa Wall.



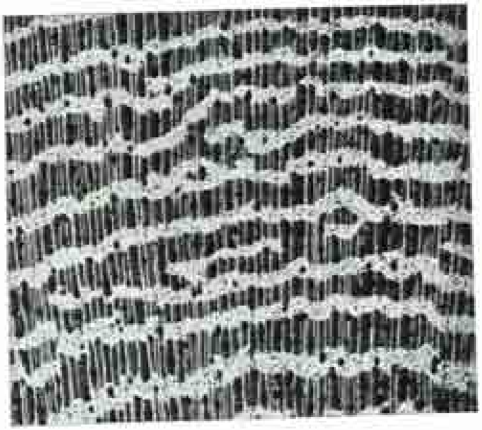
67. Garcinia spicata Hk. f.



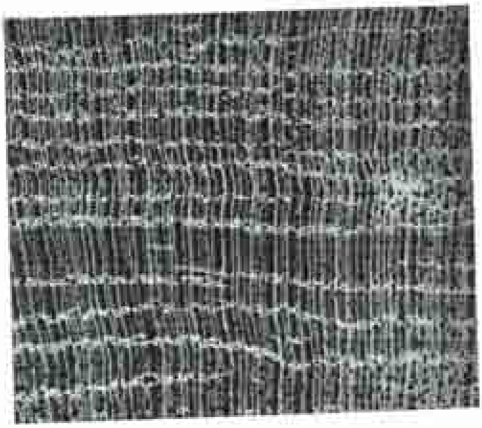
68. Garcinia xanthochymus Hk. f.



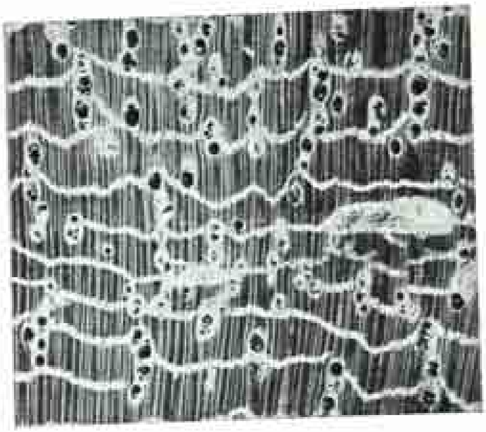
69. Garcinia xanthochymus Hk. f.



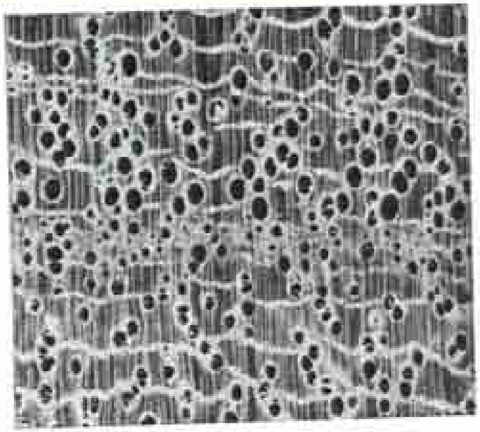
70. Kayea assamica King & Prain



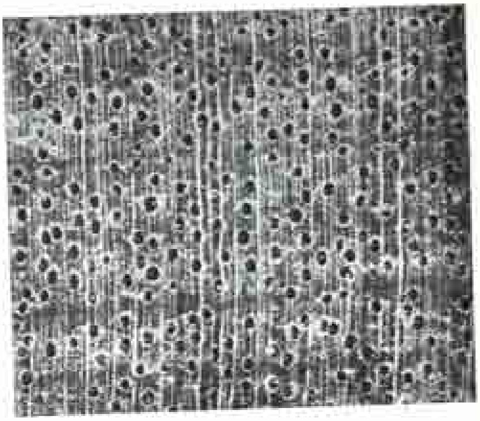
71. Kayea nervosa T. Anders.



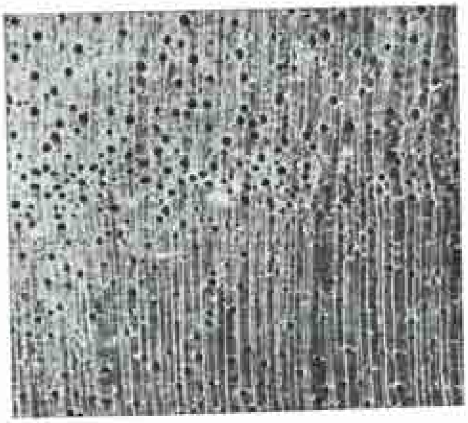
72. Mesua ferrea L.



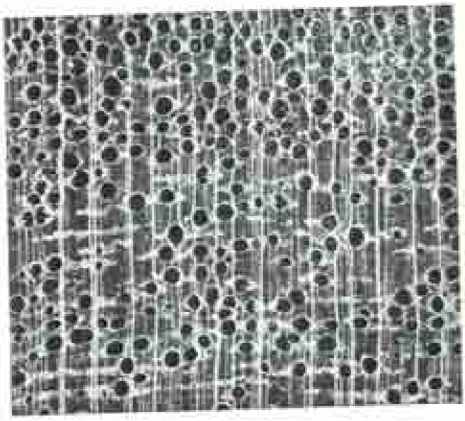
73. Mesua ferrea L.



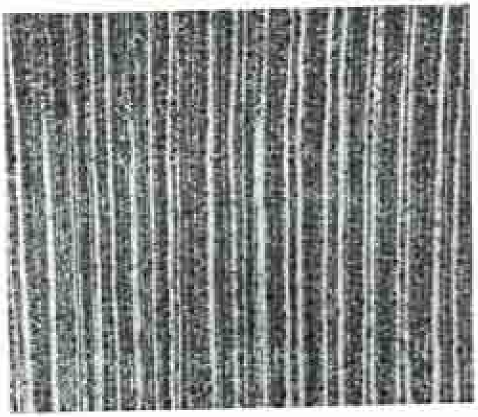
74. Ochrocarpus longifolius Benth. & Hk. f.



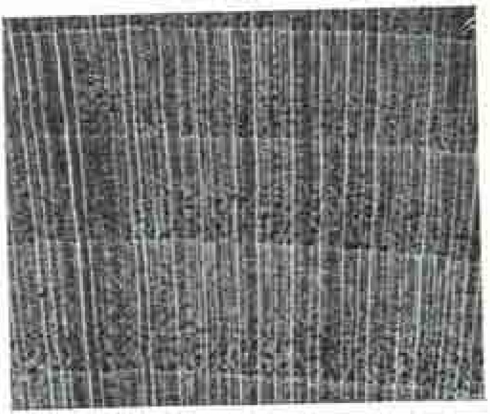
75. Poeciloneuron indicum Bedd.



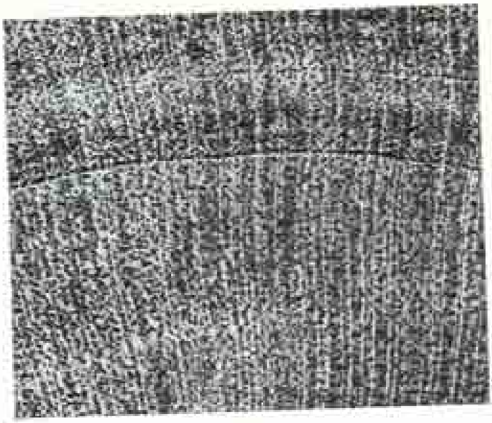
76. Poeciloneuron indicum Bedd.



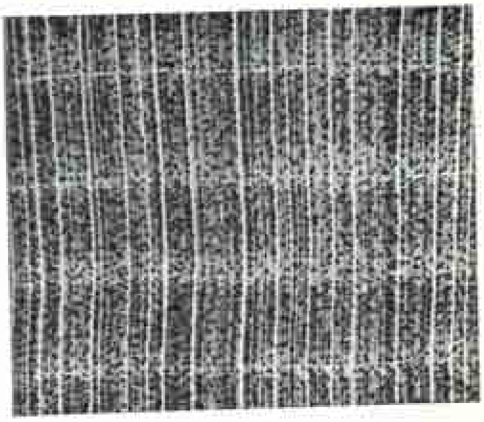
77. Anneslea fragrans Wall.



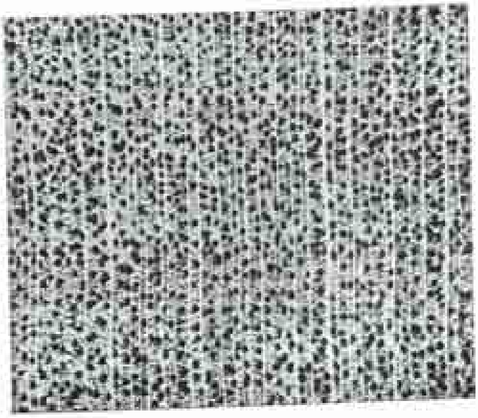
78. Camellia drupifera Lour.



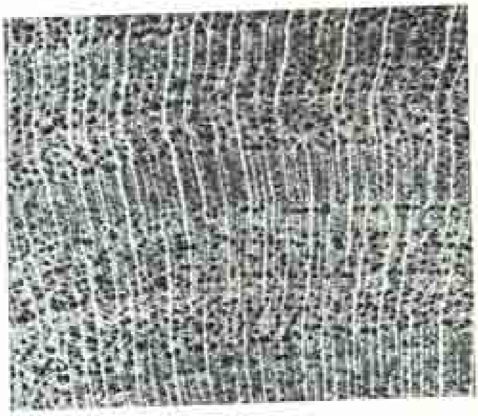
79. Camellia thea Link.
(C. sinensis (L.) O. Ktze.)



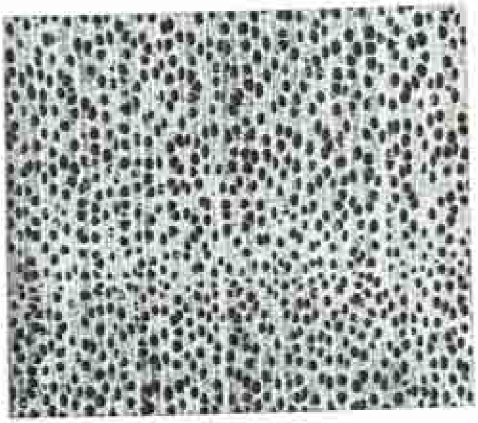
80. Eurya symplocina Blume



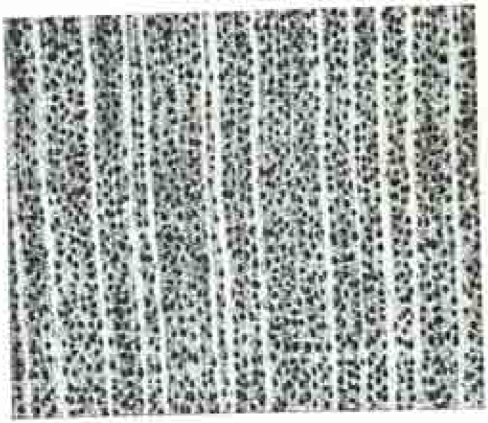
81. Gordonia obtusa Wall.



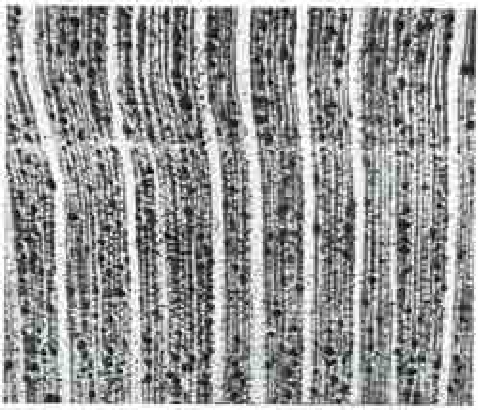
82. Pyrenaria serrata Blume



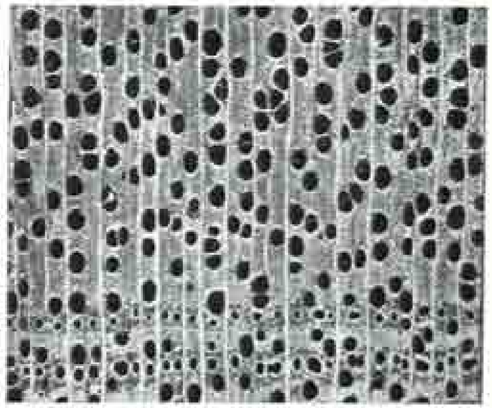
83. Schima wallichii Choisy



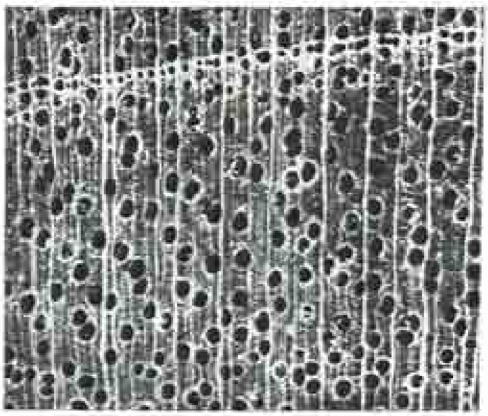
84. Ternstroemia japonica Thunb.



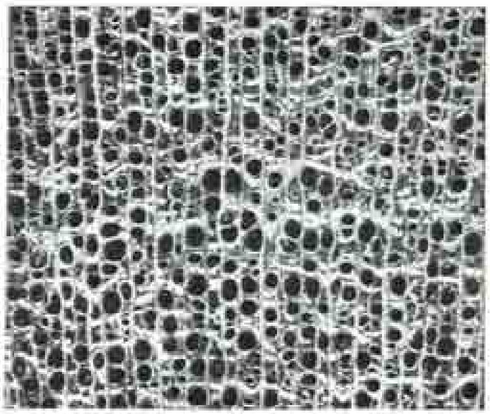
85. Saurauja griffithii Dyer
(Saurauia griffithii Dyer)



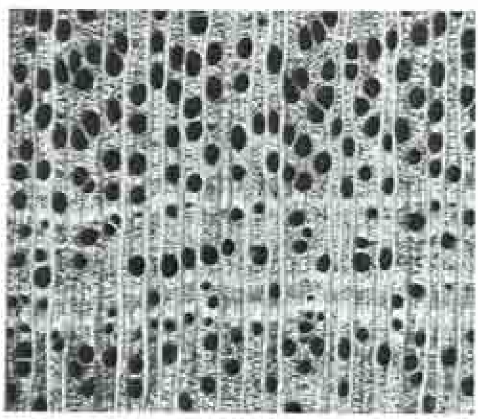
86. Anisoptera oblonga Dyer



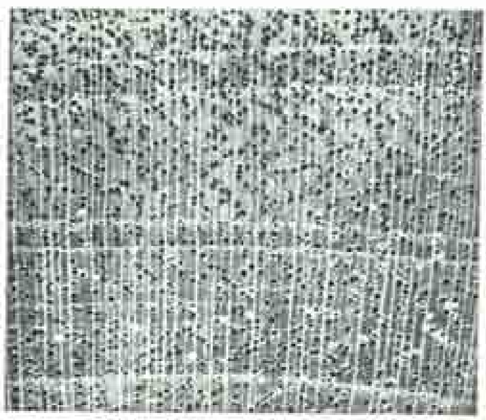
87. Anisoptera scaphula Pierre



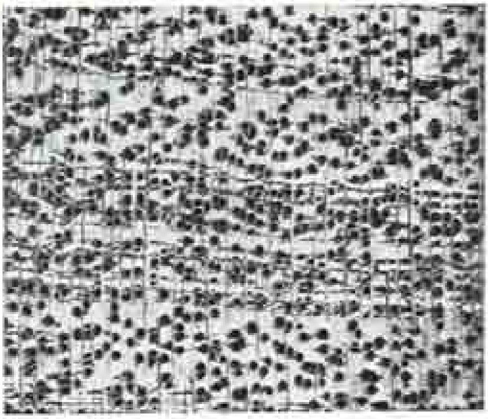
88. Anisoptera scaphula Pierre



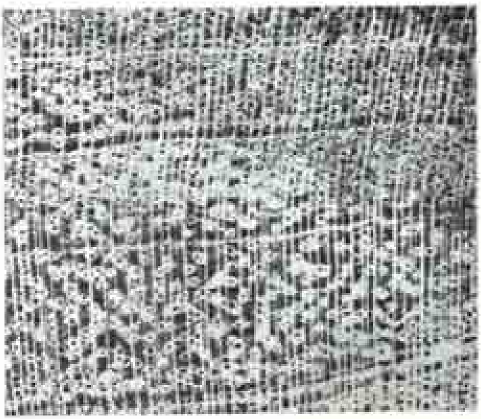
89. Anisoptera scaphula Pierre



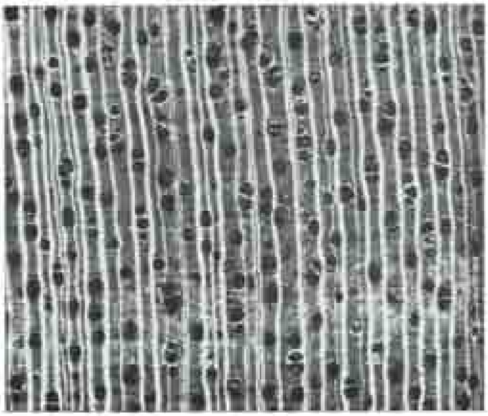
90. Balanocarpus utilis Bedd.



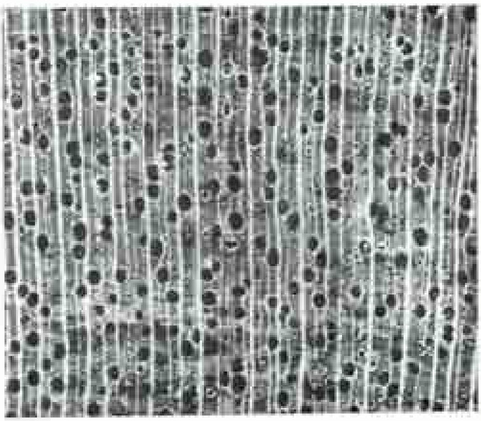
91. Balanocarpus utilis Bedd.



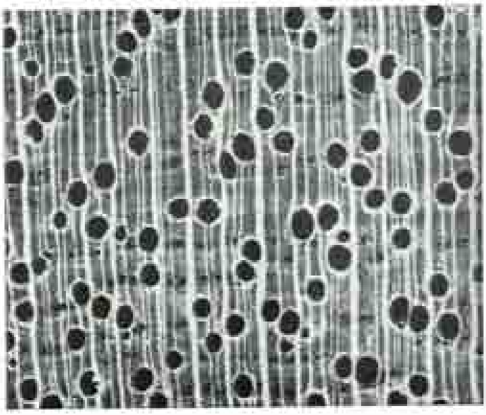
92. Dioticarpus barryi Dunn.



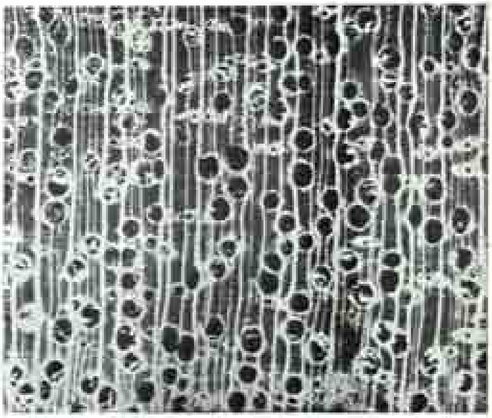
93. Dipterocarpus alatus Roxb.



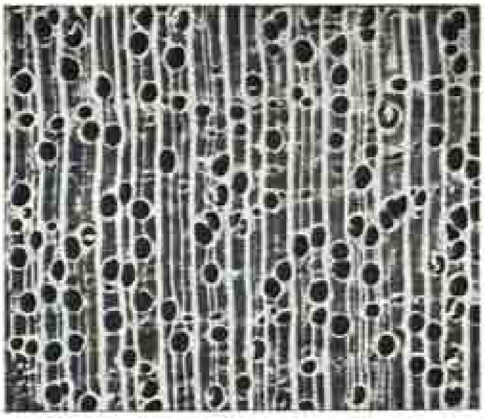
94. Dipterocarpus baudii Korth.



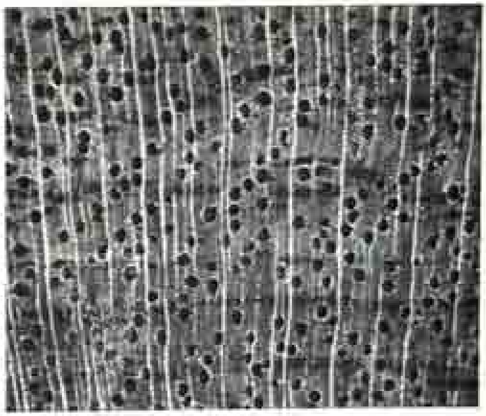
95. Dipterocarpus costatus Gaertn. f.



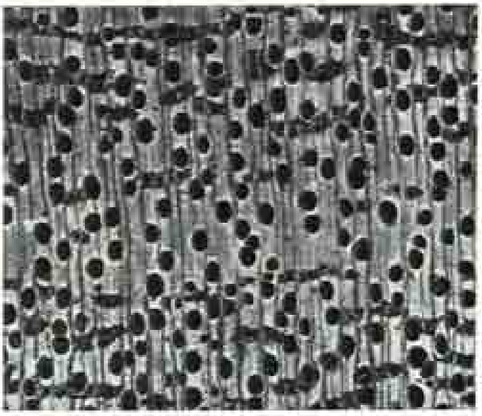
96. Dipterocarpus costatus Gaertn. f.



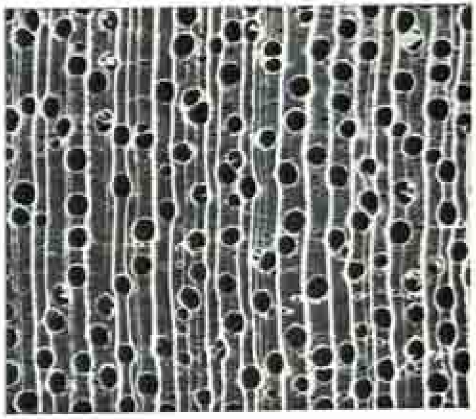
97. Dipterocarpus dyerii Pierre



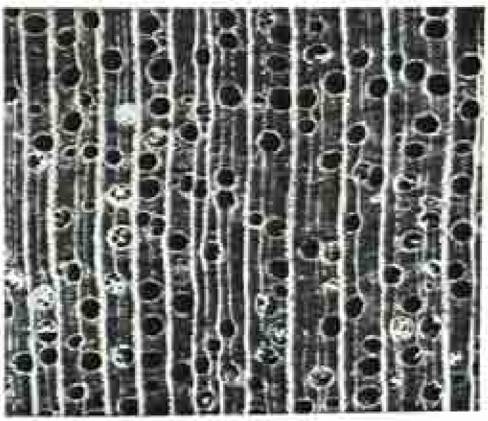
98. Dipterocarpus indicus Bedd.



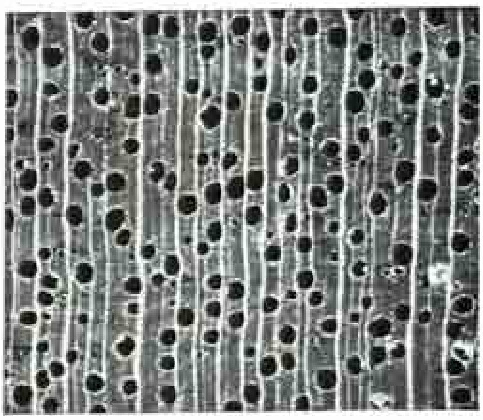
99. Dipterocarpus indicus Bedd.



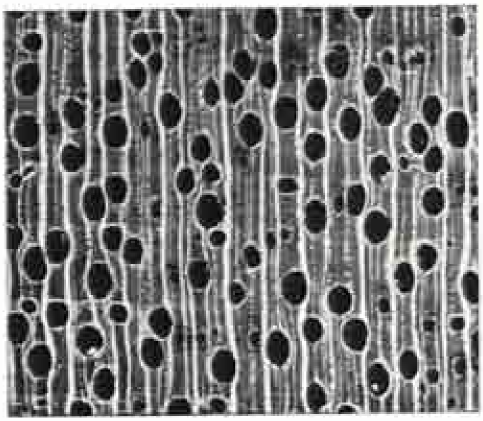
100. Dipterocarpus kerri King



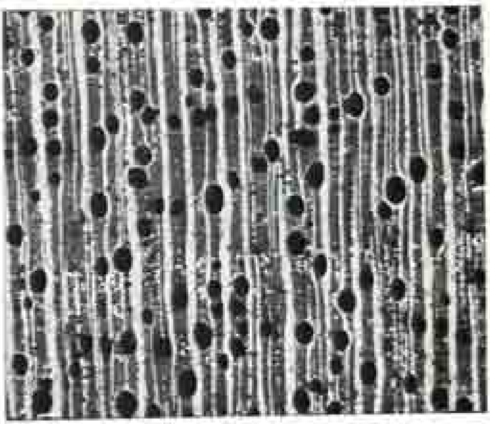
101. Dipterocarpus macrocarpus Vesque.



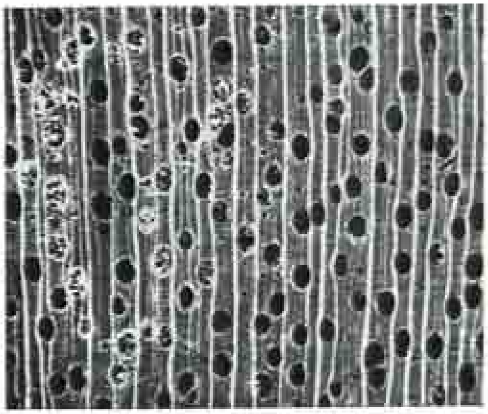
102. Dipterocarpus pilosus Roxb.



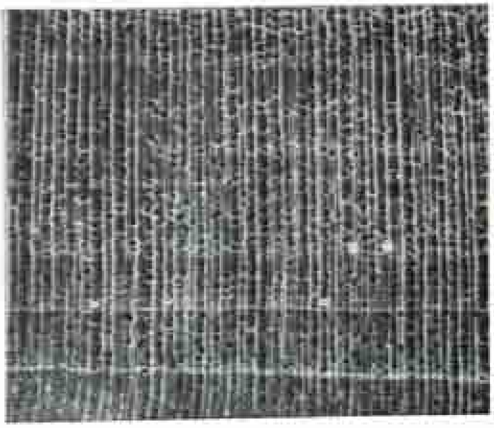
103. Dipterocarpus pilosus Roxb.



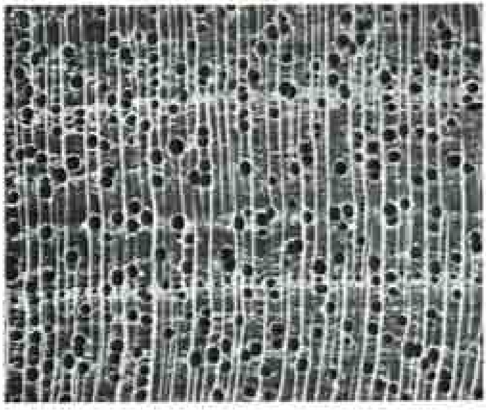
104. Dipterocarpus tuberculatus Roxb.



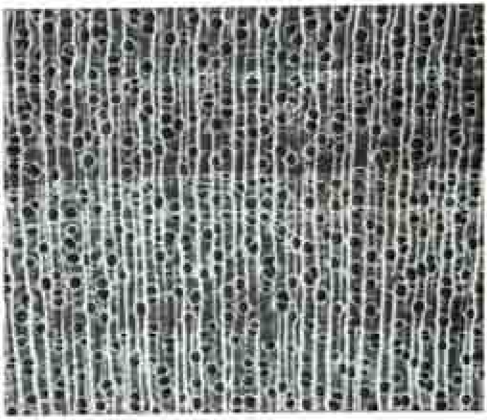
105. Dipterocarpus turbinatus Gaertn. f.



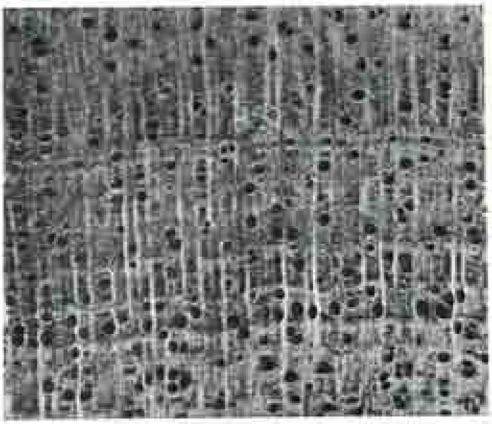
106. Hopea glabra W. & A.



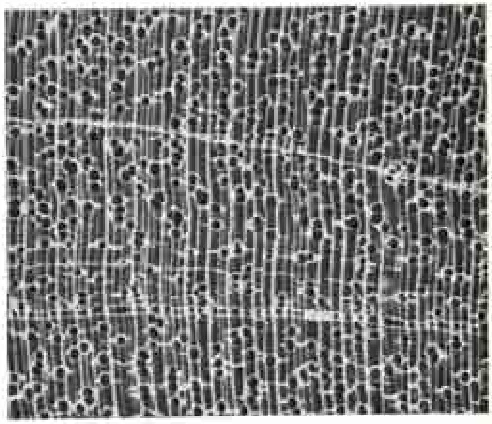
107. Hopea griffithii Kurz



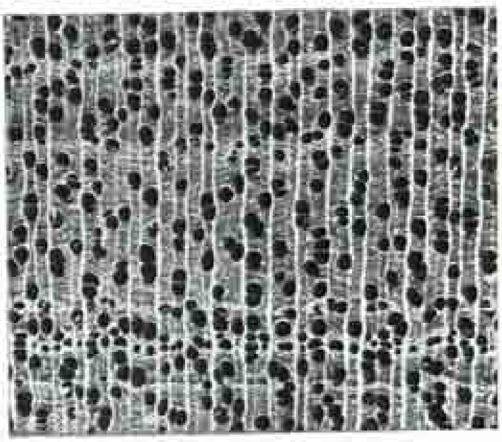
108. Hopea helferi Brandis



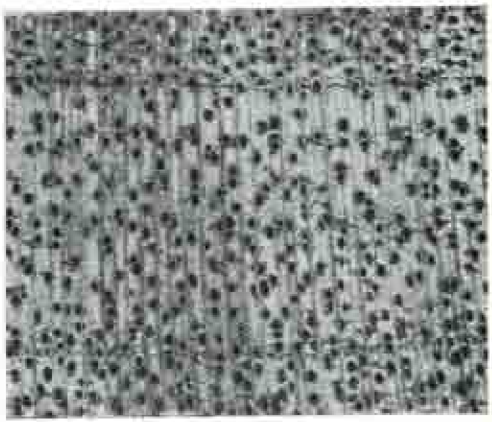
109. Hopea minutiflora Fischer



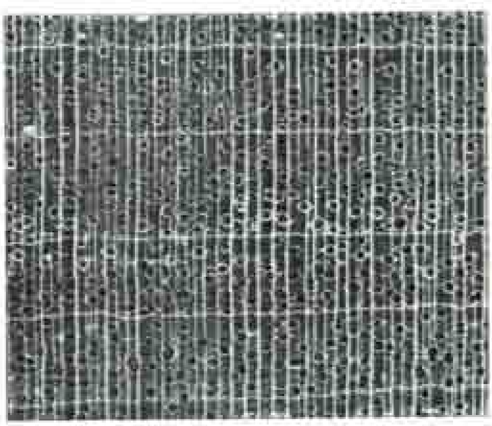
110. Hopea oblongifolia Dyer



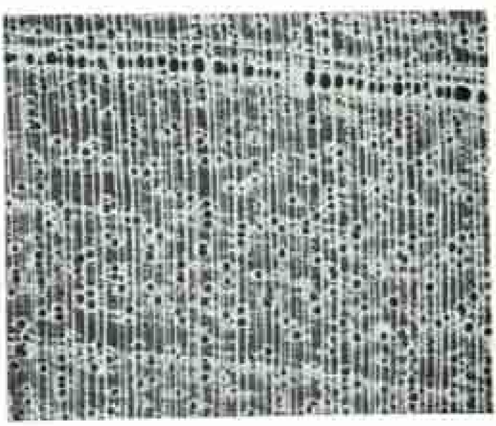
111. Hopea odorata Roxb.



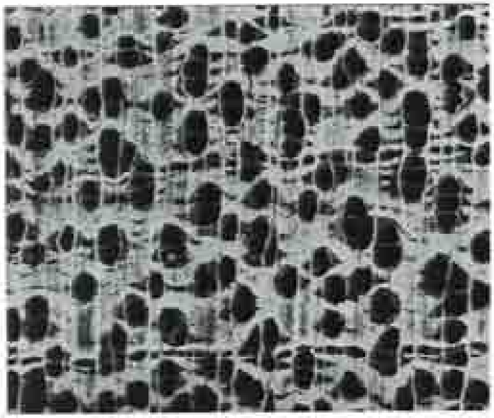
112. Hopea parviflora Bedd.



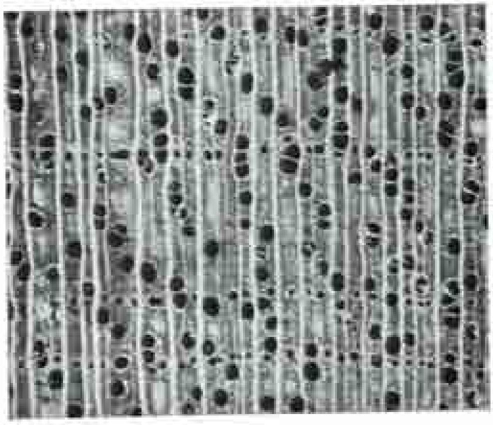
113. Hopea shingkeng (Dun) Bor



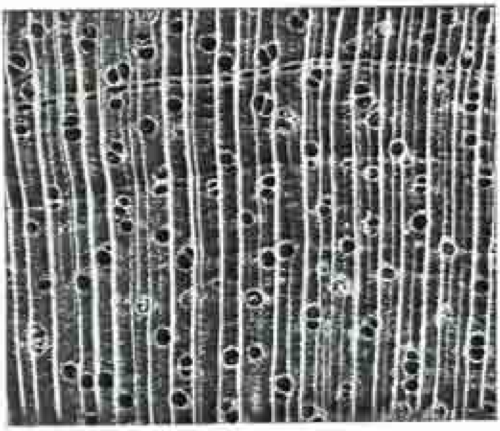
114. Hopea wightiana Wall.



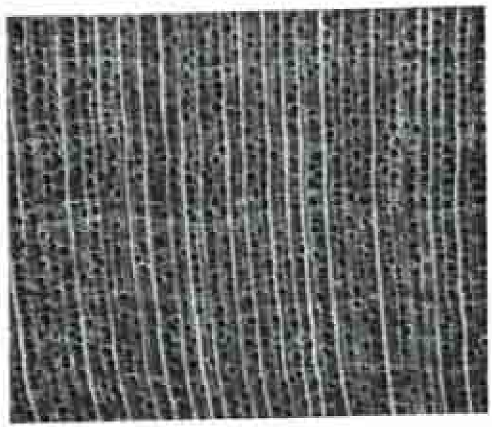
115. Parashorea stellata Kurz



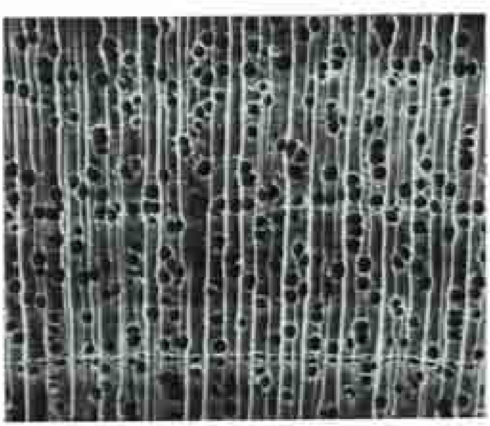
116. Parashorea stellata Kurz



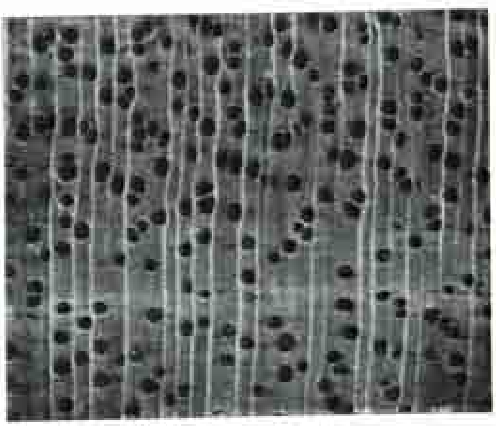
117. Pentacme suavis A. DC.



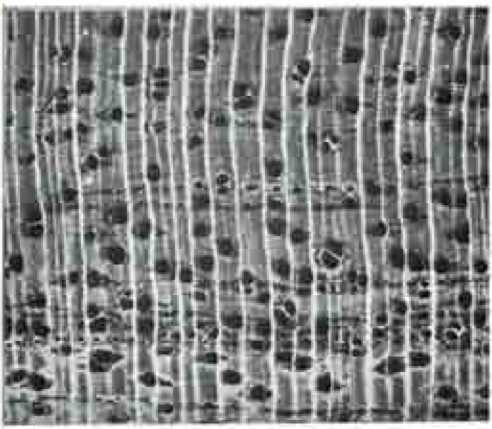
118. Shorea argentea Fischer



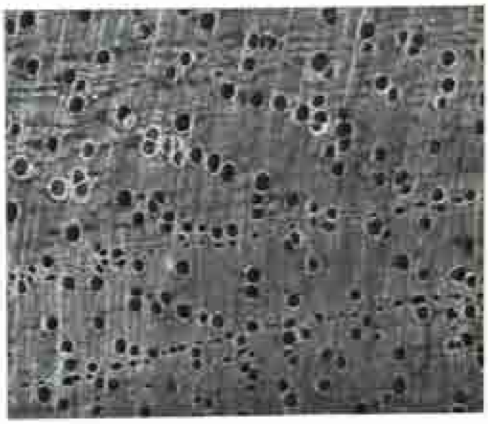
119. Shorea assamica Dyer



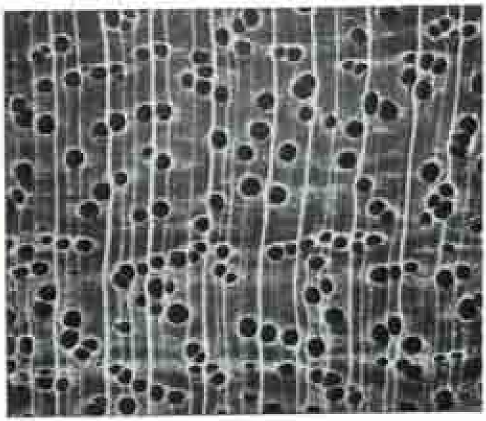
120. Shorea assamica Dyer



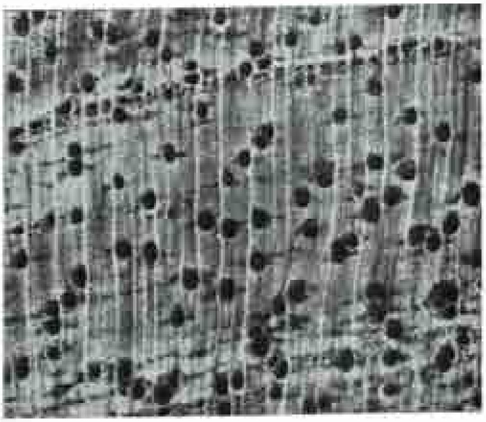
121. Shorea buchanani Fischer



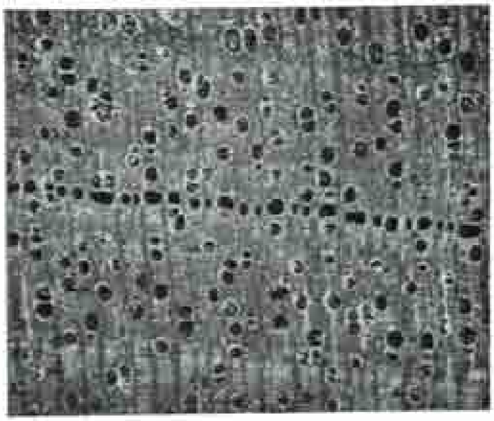
122. Shorea farinosa Fischer



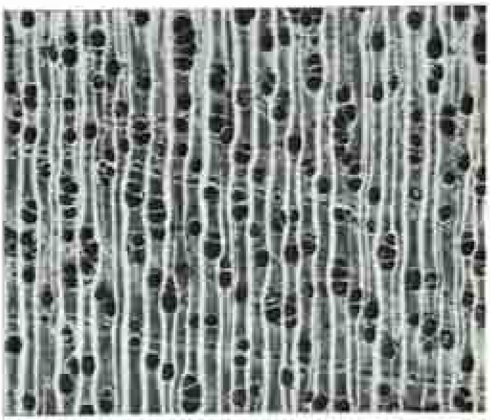
123. Shorea floribunda Kurz



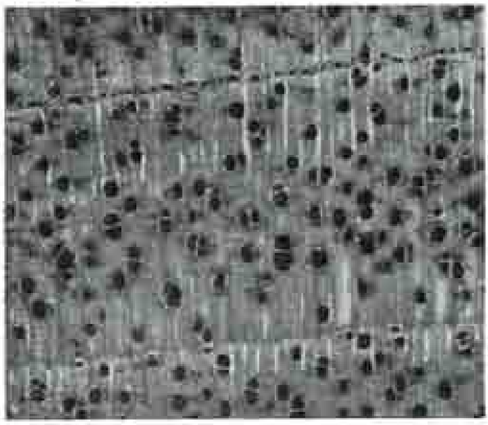
124. Shorea gratissima Dyer



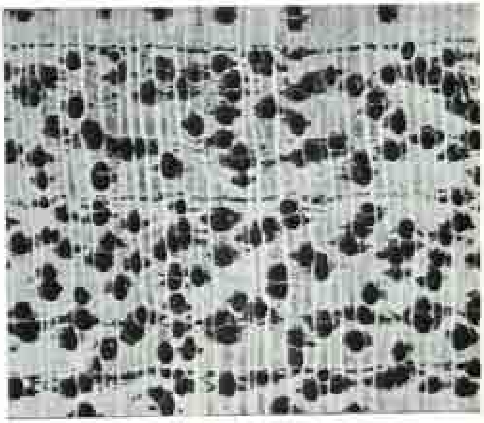
125. Shorea obtusa Wall.



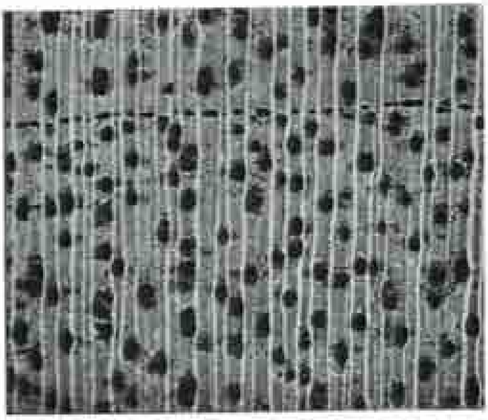
126. Shorea robusta Gaertn. f.



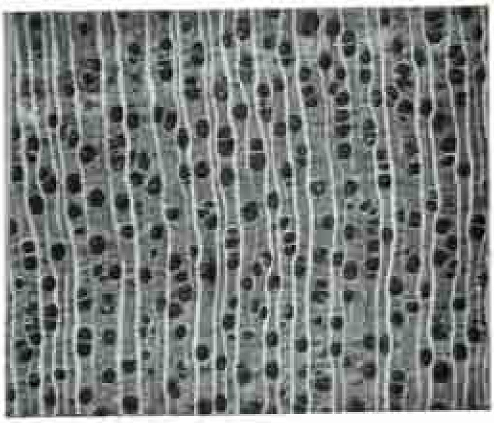
127. Shorea robusta Gaertn. f.



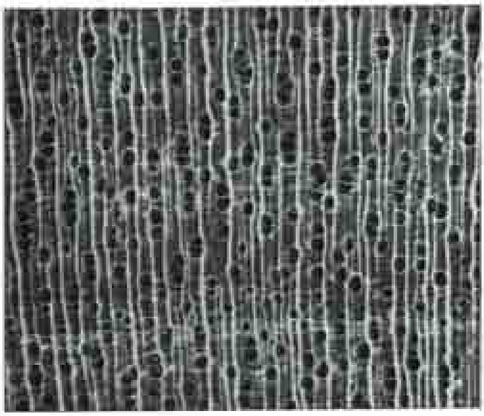
128. Shorea robusta Gaertn. f.



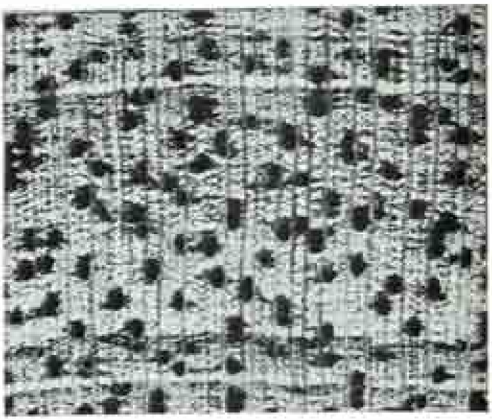
129. Shorea robusta Gaertn. f.



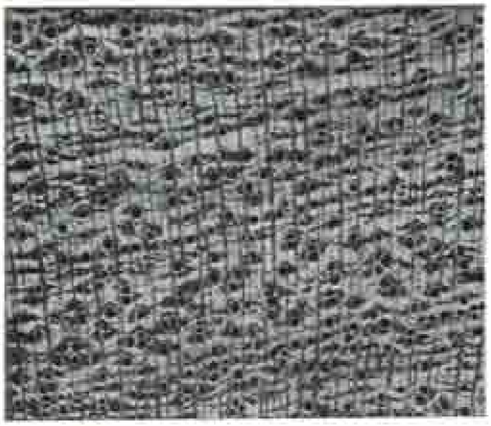
130. Shorea robusta Gaertn. f.



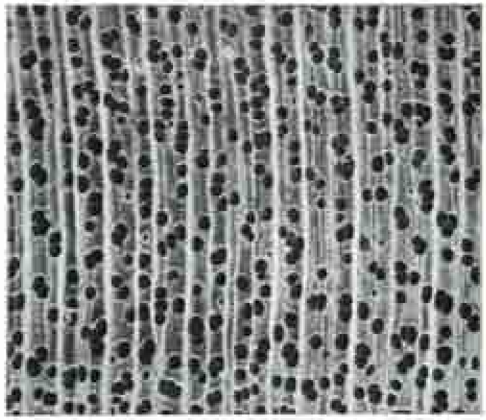
131. Shorea robusta Gaertn. f.



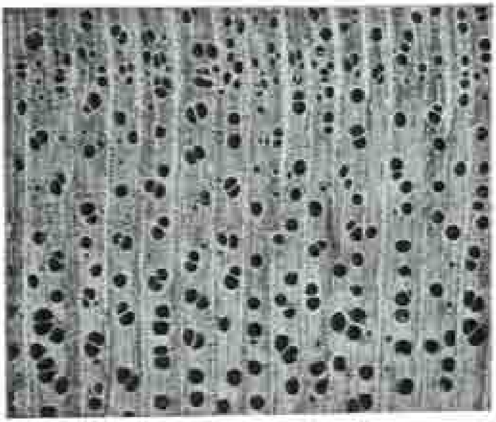
132. Shorea talura Roxb.



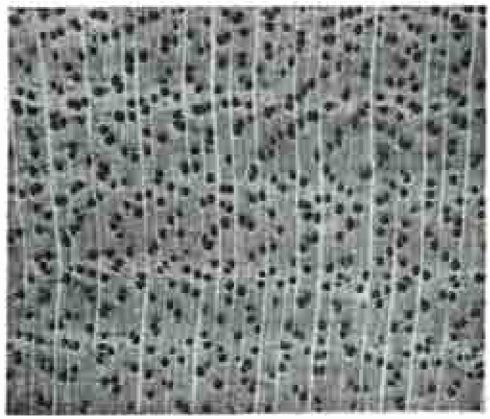
133. Shorea tumbuggaia Roxb.



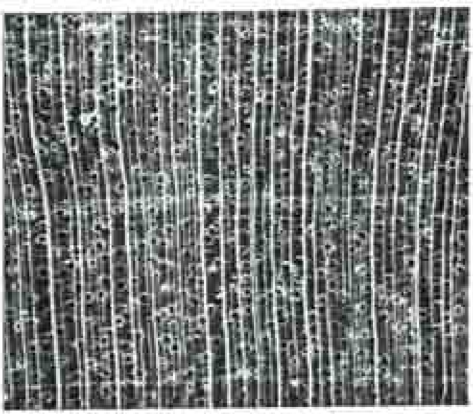
134. Vateria indica L.



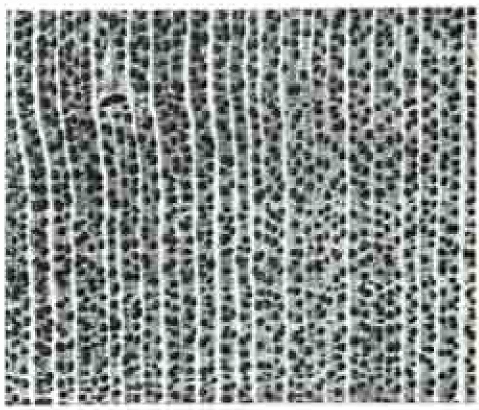
135. Vateria indica L.



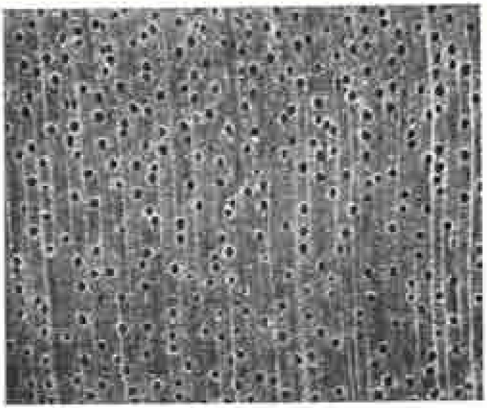
136. Vateria macrocarpa Gupta



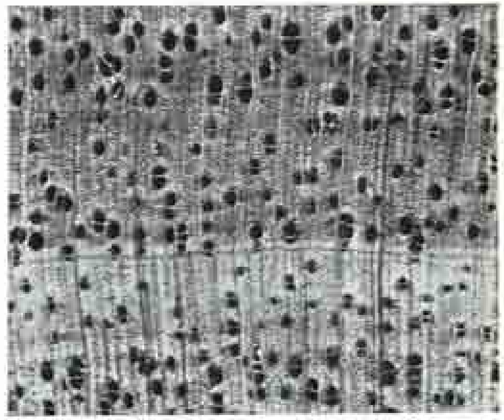
137. Vatica faginea Dyer



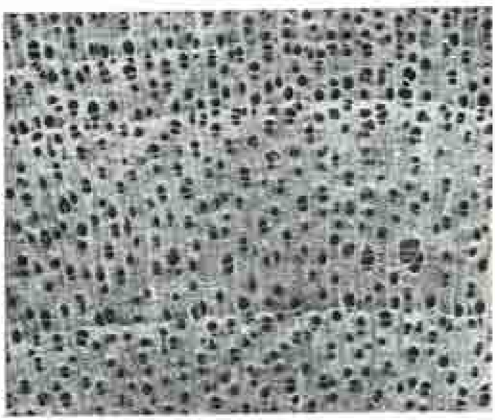
138. Vatica lanceaefolia Blume



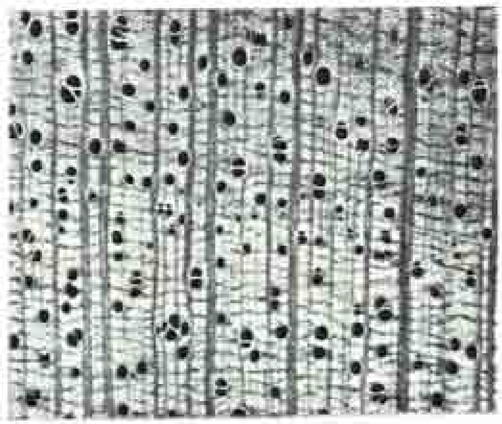
139. Vatica roxburghiana Blume



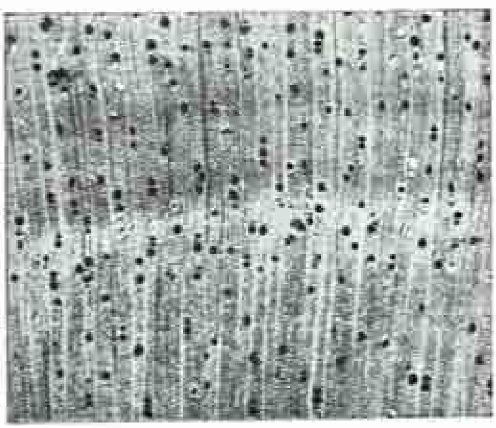
140. Hibiscus macrophyllus Roxb.



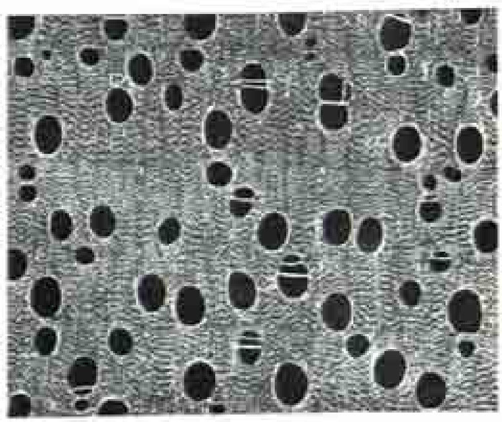
141. Hibiscus tiliaceus L.



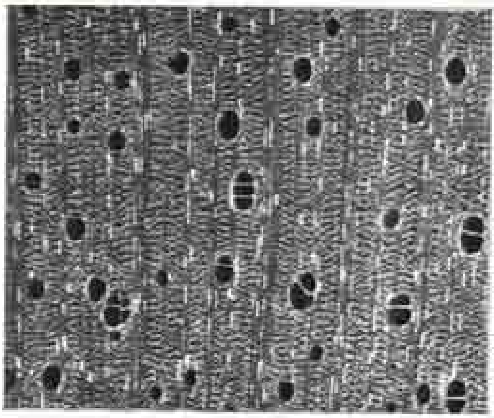
142. Kydia calycina Roxb.



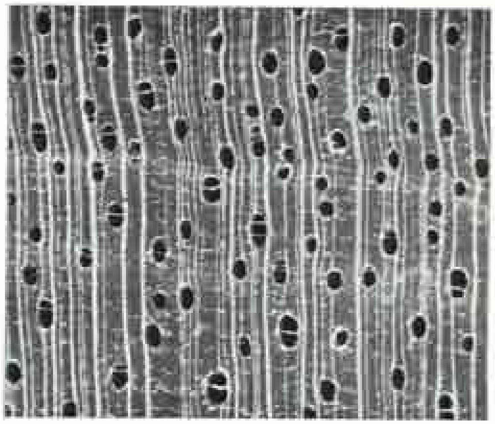
143. Thespesia populnea Correa.



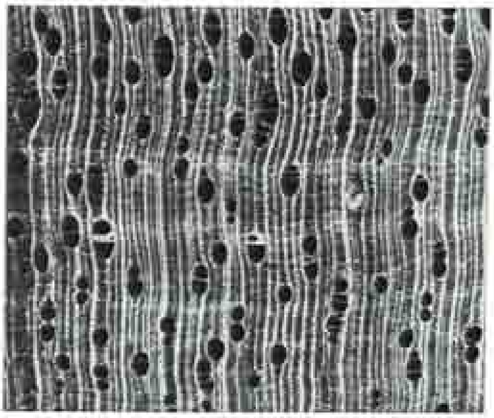
144. Bombax insigne Wall.
(Salmalia insignis Schott & Endl.)



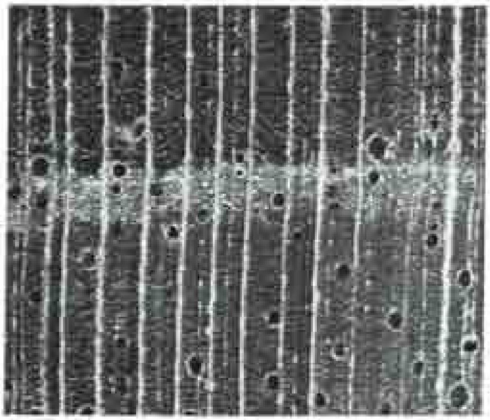
145. Bombax malabaricum DC.
(Salmalia malabarica (DC.) Schott & Endl.)



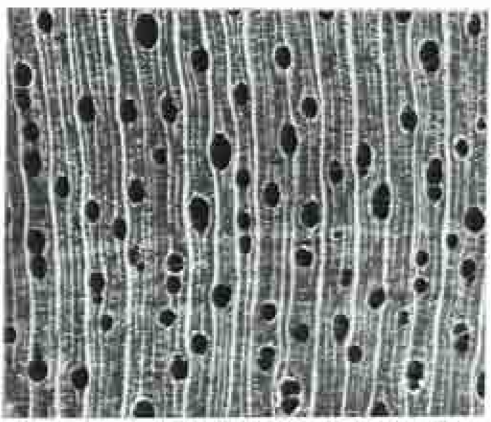
146. Cullenia excelsa Wight



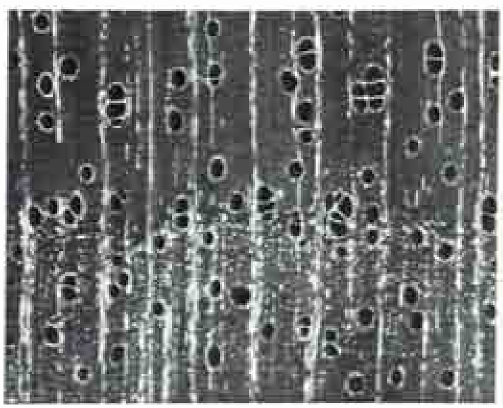
147. Durio zibethinus DC.



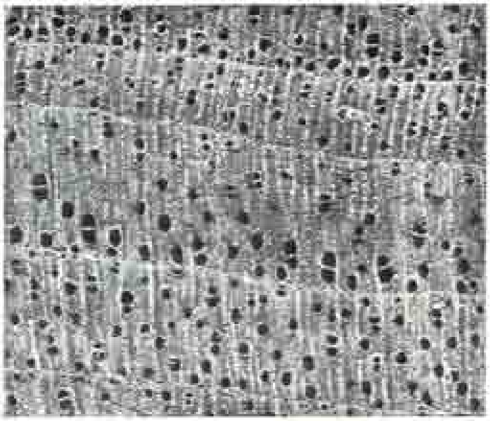
148. Eriodendron anfractuosum DC.
(Ceiba pentandra Gaertn.)



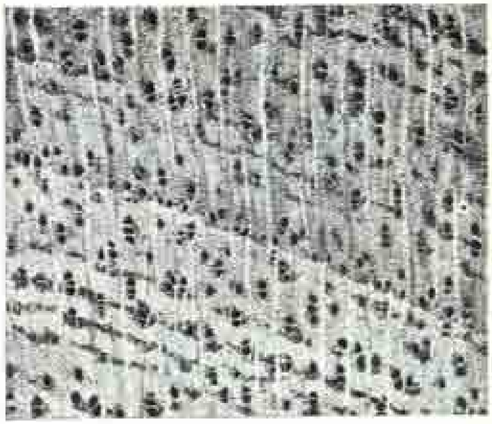
149. Neesia synandra Mast.



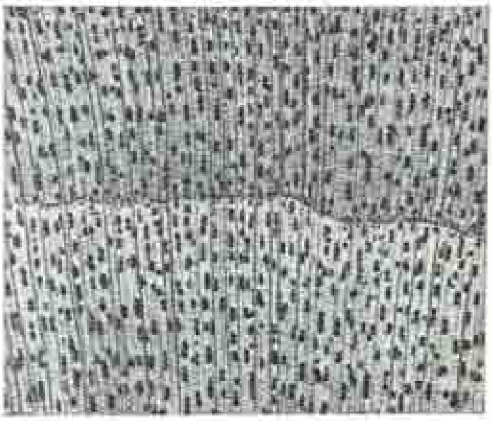
150. Ochroma lagopus Sw.



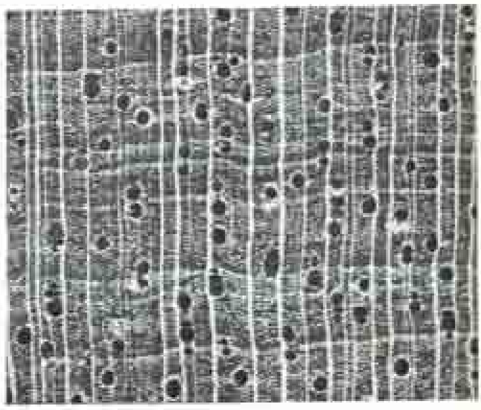
151. Eriolaena candollei Wall.



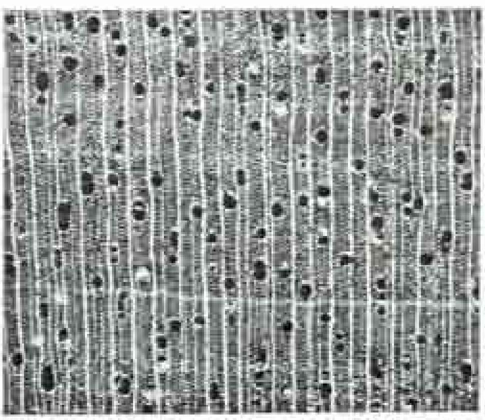
152. Eriolaena spectabilis Planchon



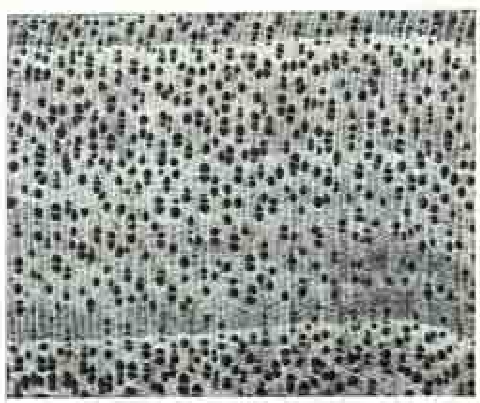
153. Helicteres isora L.



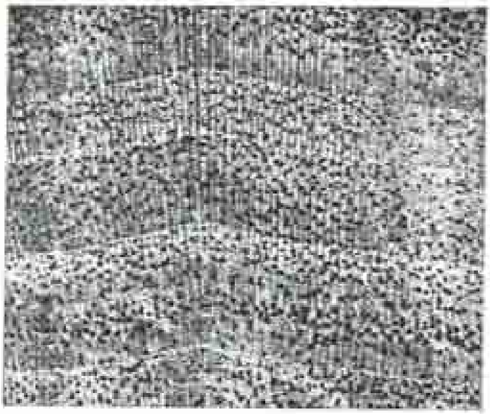
154. Heritiera acuminata Wall.



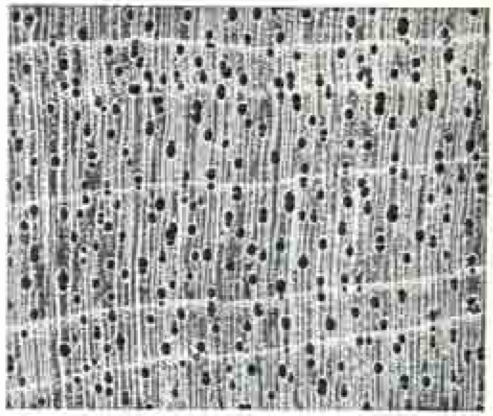
155. Heritiera littoralis Dryander



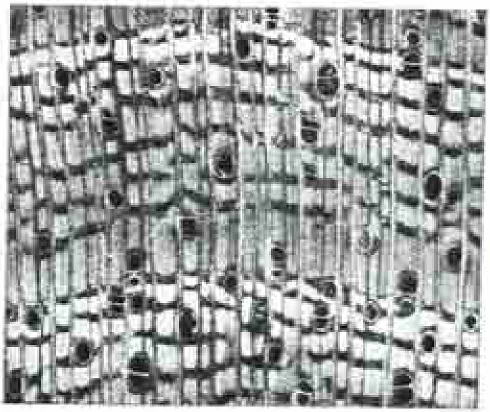
156. Mansonia depikae Purkay.



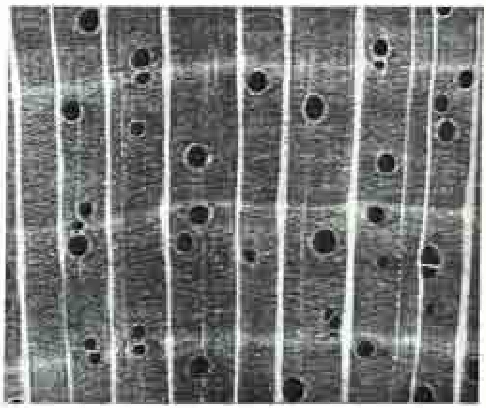
157. Mansonia gagei Drumm.



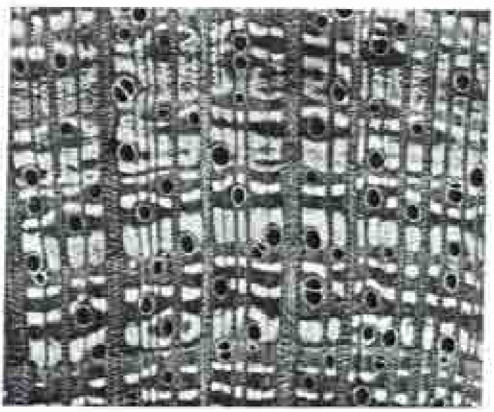
158. Pterospermum acerifolium Willd.



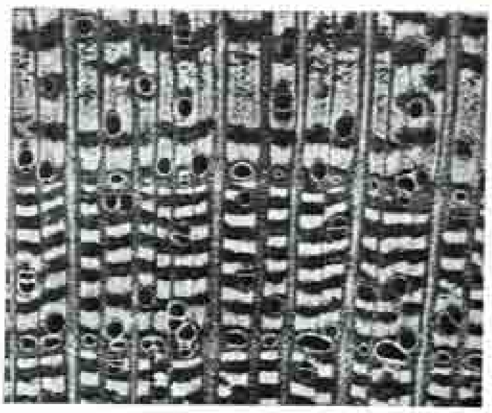
159. Sterculia alata Roxb.
(Pterygota alata (Roxb.) R. Br.)



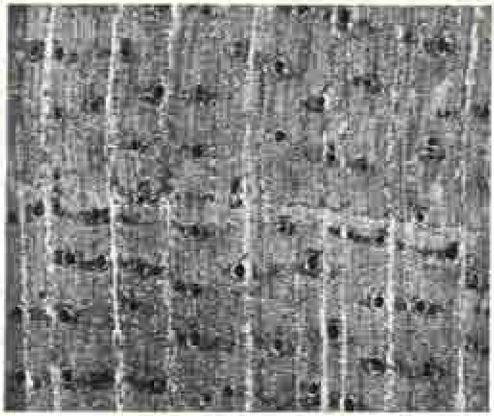
160. Sterculia campanulata Wall. ex Mast.
(Pterocymbium tinctorium (Blanco) Merr.)



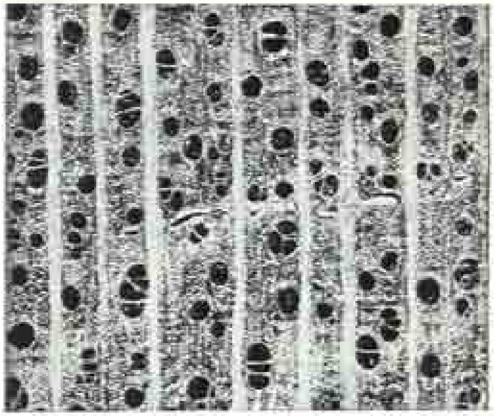
161. Sterculia coccinea Roxb.



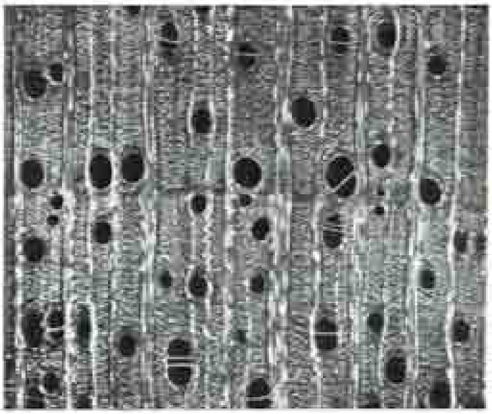
162. Sterculia fulgens Wall.
(Erythropsis fulgens Ridley)



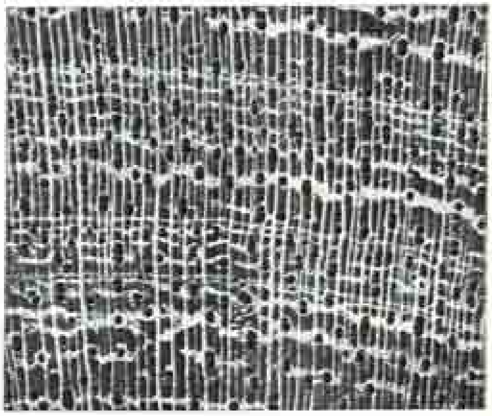
163. Sterculia scaphigera Wall.
(Scaphium wallichii Schott & Endl.)



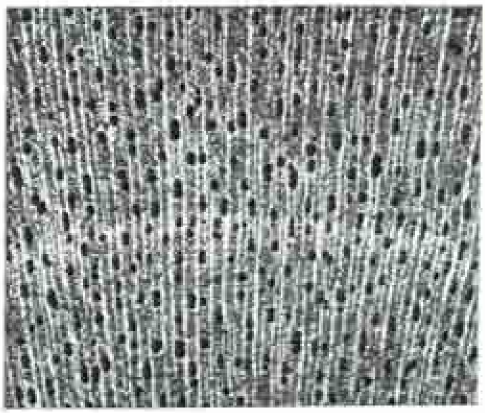
164. Sterculia urens Roxb.



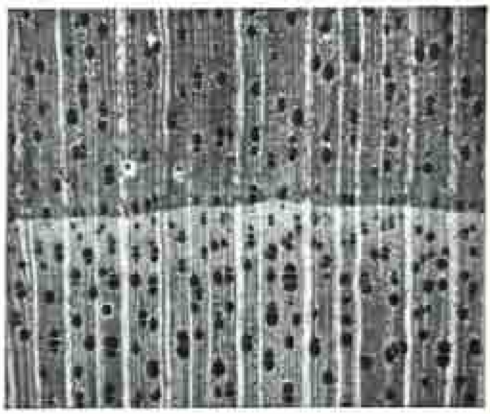
165. Sterculia villosa Roxb.



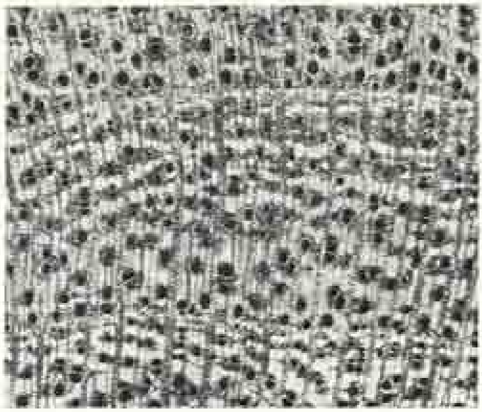
166. Berrya ammonilla Roxb.



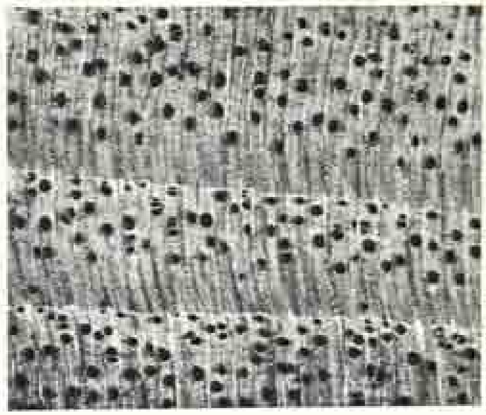
167. Brownlowia elata Roxb.



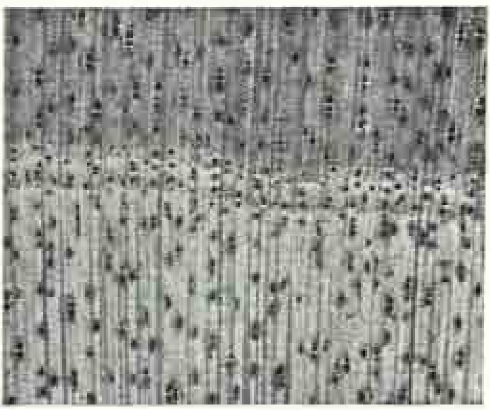
168. Columbia floribunda Wall.



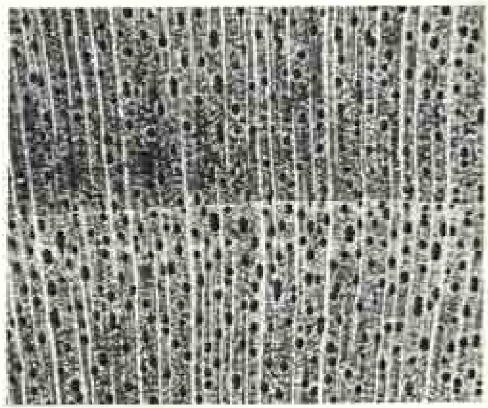
169. Erinocarpus nimmonii Graham



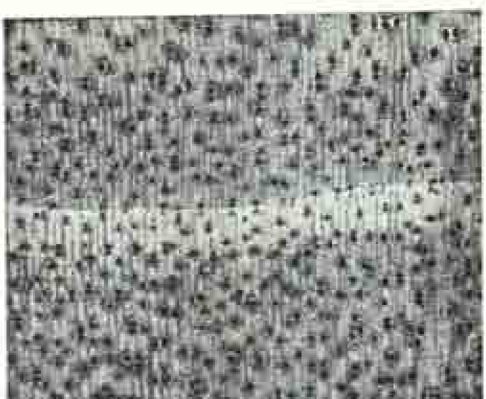
170. Grewia elastica Royle



171. Grewia laevigata Vahl

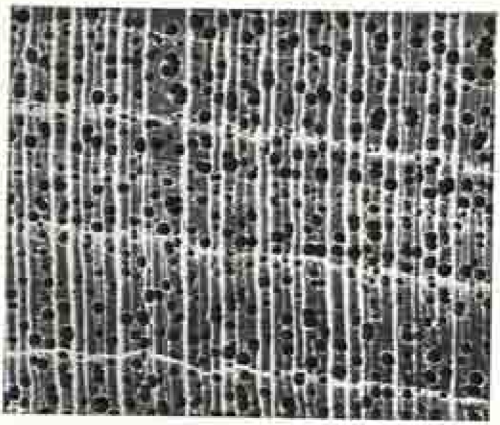


172. Grewia microcos L.
(Microcos paniculata L.)

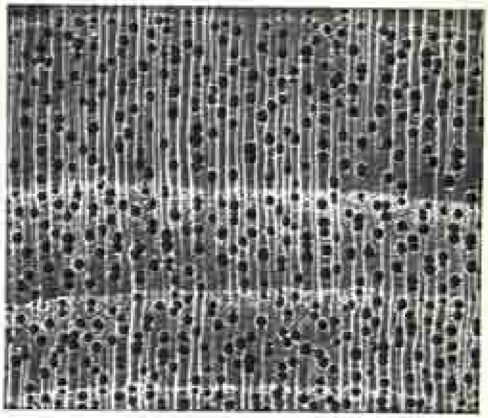


173. Grewia oppositifolia Roxb. ex Mast.

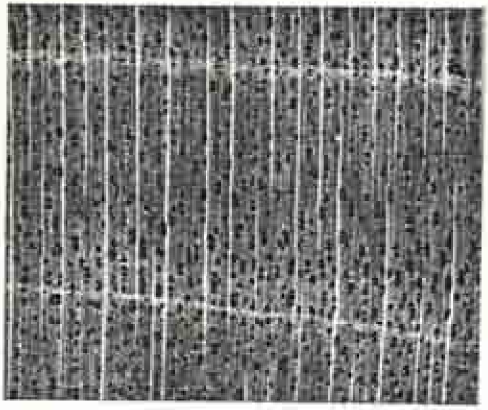
174. Grewia pilosa Lam.



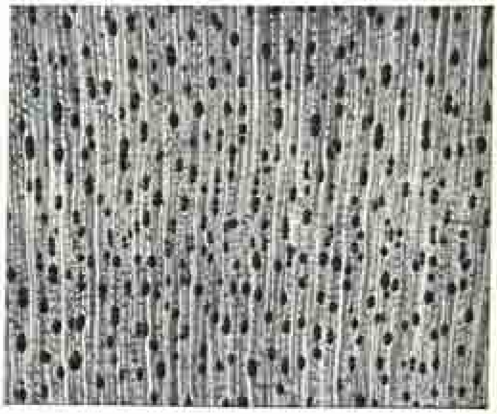
175. Grewia tiliaefolia Vahl



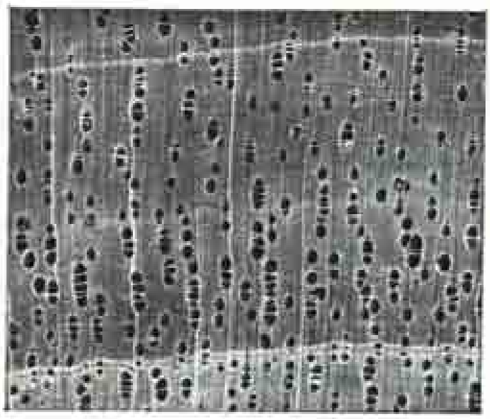
176. Pentace burmanica Kurz



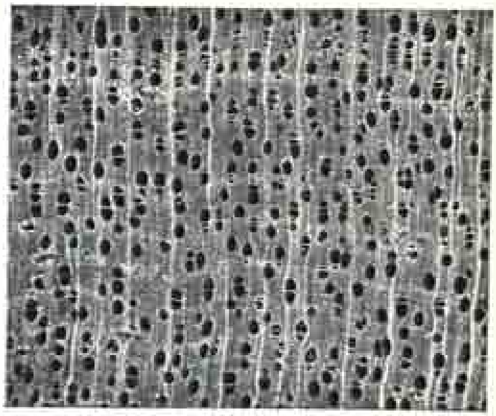
177. Echinocarpus assamicus Benth.



178. Elaeocarpus floribundus Blume



179. Elaeocarpus ganitrus Roxb.



180. Elaeocarpus robustus Roxb.